

The AMSAT[®] Journal

Editor
JoAnne Maenpaa, WB9JEJ

Editorial Staff
John Bubbers, W1GYD
Haley Hintze

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Saudisat-1C (SO-50), Unisat-2, Latinsats, Rubin-2 containing the SAFIR-M payload (AO-49), and the Trailblazer satellites shown being prepared for the December 20, 2002 launch aboard a Russian modified SS-18 ICBM. Photo credits: Professor Filippo Graziani (Unisat-2) and Oliver Amend, DG6BCE, (Rubin-2). Thanks to Don Woodward, KD4APP for research and labeling of the satellites.

Oscar Count Reaches 50

By JoAnne Maenpaa, WB9JEJ

Starting with OSCAR-1 launched in December 1961, Amateur Radio has achieved its 50th satellite. This month two new satellites have begun operations. The SAFIR-M amateur radio and educational payload aboard Germany's research-based RUBIN-2 satellite was designated AATiS OSCAR-49 (AO-49). SaudiSat-1C was named Saudi OSCAR-50 (SO-50). Both shared a December 20, 2002 launch aboard a Russian modified Soviet era SS-18 ICBM from the Baikonur Cosmodrome.

[continued on page 4]

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 AMSAT-NA WWW: <http://www.amsat.org>

The AMSAT Journal Staff

Editor-in-Chief: JoAnne Maenpaa, WB9JEJ
Associate Editor: Haley Hintze
Circulation: Martha Saragovitz
 (martha@amsat.org)
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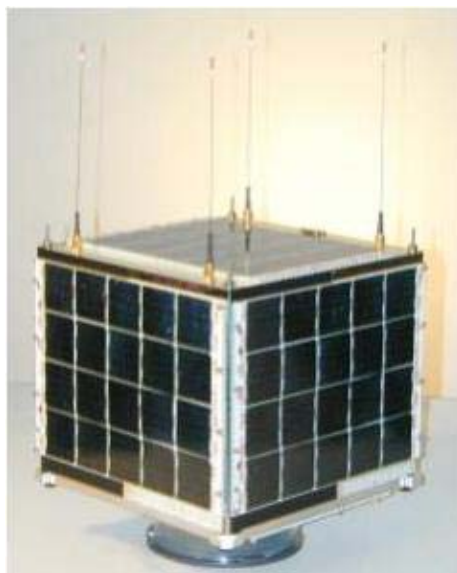
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Apogee View

I am pleased to report that the Echo team is working hard to provide us all with the new satellite on schedule. If the launch is on time, Echo should be in orbit by the end of this year. As of January 10, SpaceQuest is almost complete with their work and the remaining AMSAT items are progressing well, even if they are on a tight schedule. The Echo team has been expanded and now incorporates several of our previous "P3D" experts including Chuck Green, Jim White, Stan Wood, Lyle Johnson and Bob Diersing, to name a few. The potential users of Echo are looking forward to the launch and use from this very exciting satellite.



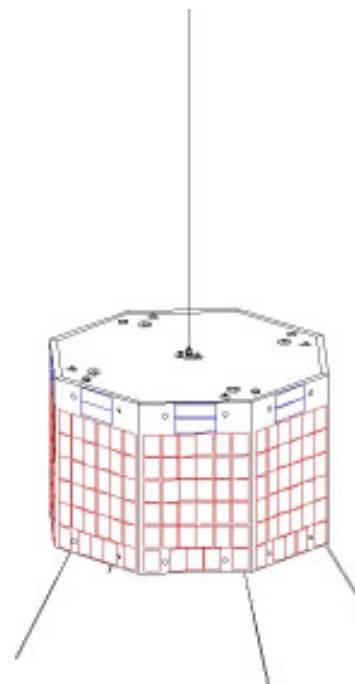
*Mechanical Model of
 AMSAT OSCAR-Echo Class Microsat*

In November 2000 P3D was launched and shortly thereafter was named AO-40, by our Chairman of the Board Bill Tynan W3XO. On January 4, 2003, Bill designated SaudiSat 1C as SO-50. It is a remarkable achievement to have 10 amateur satellites launched in only 25 months. Not all are still operable, as some were designed for a short life. Other satellites, despite the criticism or doubts, are providing service to the amateur community. To my knowledge at least six additional satellites are in different stages of design, development, building or testing. Any mode you want to work is probably being evaluated and designed for at this time. This was accomplished despite the slowdown in the economy and the related reduction in funding, which is very evident. However, I am pleased to announce that in 2002 we achieved a total of \$90,075 in donations. I would like to send a big thank-you to all of you who were able to donate toward AMSAT-NA.

Our goal for 2003 is to establish a funding amount equivalent to \$100US for every AMSAT member. While we may be dependent on members' contributions and donations for a majority of this amount, your Board of Directors will be considering other opportunities at a Board meeting to be held at the end of February. Your suggestions and ideas on funding our satellites are very welcome and should be sent to me by e-mail (ve3frh@amsat.org) as soon as possible and at least by the middle of February. To quote a phrase, "It seems to us" that the our main impediment in satellite development is *funding*, and we need to have more ideas and *fund-raising volunteers* who are prepared to run with the ideas.

Thinking ahead, we are looking for a suitable place to hold the 2004 Space Symposium and annual meeting. Traditionally, we have always decided on the next place to hold our meetings one year in advance, which provides an opportunity for the convener to attend the previous meeting and see the format, and allows for time to develop new ideas for inclusion in their subsequent symposium. If you would like your town or city to be considered (or reconsidered) for the 2004 event please contact me.

73,
 Robin Haighton VE3FRH
 President



Unisat-2



The RUBIN-2 satellite being prepared for launch. It was hidden from view in the photo on page 1.

continued from page 1 ...

AO-49, SAFIR-M is the project of a German group called Arbeitskreis Amateurfunk und Telekommunikation in der Schule, or AATiS e.V. This translates into the Working Group for Amateur Radio and Telecommunications in Schools. SAFIR-M was developed in close cooperation with the University of Applied Sciences in Pforzheim, Germany under the leadership of Henning Rech, DF9IC. Oliver Amend, DG6BCE, the project manager for SAFIR-M, says that additional information about AO-49 is available on-line at these two web pages: <http://amend.gmxhome.de> (SAFIR-M homepage) and <http://hft.ft-pforzheim.de/ao49> (SAFIR-M operations). The downlink is on 145.825 MHz with an uplink frequency of 435.275 MHz. The main operating mode is AX.25 9600 baud telemetry with an optional voice beacon. 1200 baud packet is supported on the uplink. The satellite's Amateur Radio callsign is DP0AIS.



The SAFIR-M payload module aboard RUBIN-2

SO-50, SaudiSat-1C is a project of the Space Research Institute of the King Abdulaziz City for Science and Technology (KACST), an independent scientific organization of the Saudi Arabian government. Dr. Turki Al Saud, the director of the KACST Space Institute said that SaudiSat-1C carries several experiments, including a new Mode J FM amateur repeater. The downlink frequency is 436.800 MHz. The uplink frequency is 145.850MHz. A 67.0-Hz CTCSS tone is required for on-demand access to the satellite, which shares the same frequencies as AO-27 and SaudiSat-1A.

SO-50's receive antenna is a single element quarter wave whip on top of the spacecraft, feeding a VHF receiver with -124 dBm sensitivity, while the UHF transmitter is coupled to a quarter wave antenna element on the bottom of the spacecraft, radiating 250mW of RF energy. The satellite will be available for Amateur Radio communications as power permits aboard the spacecraft.

The SaudiSat web page is available on-line at <http://saudisat.kacst.edu.sa/>.

Launched two years ago, SaudiSat-1A (SO-41) and SaudiSat-1B (SO-42) may also become available for Amateur Radio service. Dr. Al Saud told AMSAT-NA, "SaudiSat-1A (SO-41) recently has been used to conduct some tests and will return to service soon. SO-41 has been configured for FM voice repeater operation. SaudiSat-1B (SO-42) still is being used to conduct some experiments but could be made available for amateur use in the future." The SaudiSat series is equipped with capabilities to provide vital data concerning weather conditions and oil exploration as well as to monitor the movement of vehicles in remote regions of Saudi Arabia.

Upon issuing the OSCAR designators, Bill Tynan, W3XO, AMSAT-NA board chairman, extended congratulations on behalf of AMSAT to the AO-49 and SO-50 project members.

The author thanks the American Radio Relay League, AMSAT News Service, Oliver Amend, Dr. Turki Al Saud, and Don Woodward for their contributions to this article. ■



(above and below) The SS-18 missile shown at liftoff. Although modified from its original purpose, the SS-18 is still launched from an underground silo.



President's Letter

Time seems to go very quickly and before I realize what is happening it is time for another newsletter. As you are aware, AMSAT-NA tries to hold its Annual meeting and Space Symposium in a different part of the continent each year. This allows a number of people to attend when it is in their local area, particularly those who cannot travel any distance. This year we will be returning to Toronto, Canada and it is some six years ago that we were there. Toronto is easy driving from many of the US North Central States with expressways leading almost to the Hotel door. A web site is being set up and will be fully accessible from the AMSAT web page.

We are now looking for volunteers to hold the 2004 meeting and it would be great to have that settled before this year's meeting in order to give the 2005 organizers a "look" at our format. Please send your offers to me at VE3FRH@amsat.org preferably to arrive before our next Board of Directors meeting which will be held in Silver Spring MD. on March 1st 2003.

As I have asked a number of officers to be present at this BoD meeting, space will be very limited. The meeting will be open to members however, there may be certain topics at which only the elected and specific appointed officers may be present. If you would like to attend, please let me know in advance, and any remaining space will be allocated on a first request basis. This board meeting will look at the allocation of our funds for building satellites, and at all of our financial matters.

I am pleased to announce that the "President's Club" is attracting donors. However the reduction in economic activity in the USA is being reflected in the total number who are donating. Although he does not know it (yet) Richard Haxton KC3AN is our 100th President's Club Core Donor. Richard is a Life Member of AMSAT so it is not possible to extend his membership, I will have to think of another way to reward him. Meanwhile "Congratulations to Richard".

Who will be the 200th New Core Donor and the recipient of a one year membership? For your information there are currently 18 Gold Donors, 12 Silver Donors, 18 Bronze Donors and 100 Core Donors. Although this is quite a substantial number we do need to have an average income per member of about \$100 and we are still quite a long way from that goal - can you help?. ... *continued on page 31*

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PROCEEDINGS OF THE AMSAT-NA
20th Space Symposium and AMSAT Annual Meeting
Held November 7 - 11, 2002 in Fort Worth, Texas

A partial listing of the contents includes the following:

- * **Microsat Design - What do People Want?**
by Richard Hambly W2GPS
- * **So You Want to Build a Satellite! - Revisited**
by Dick Jansson WD4FAB
- * **AMSAT OSCAR-E Project Status Update - A New LEO Satellite from AMSAT-NA**
by Richard Hambly W2GPS
- * **How Kids Can Talk to Space People (who are aboard the International Space Station)**
by Gene Chapline K5YF
- * **Proposal for a FEC-Coded AO-40 Telemetry Link**
by Phil Karn KA9Q
- * **A K-Band Receiver for AO-40 (for less than a king's ransom)**
by Gerald Brown K5OE

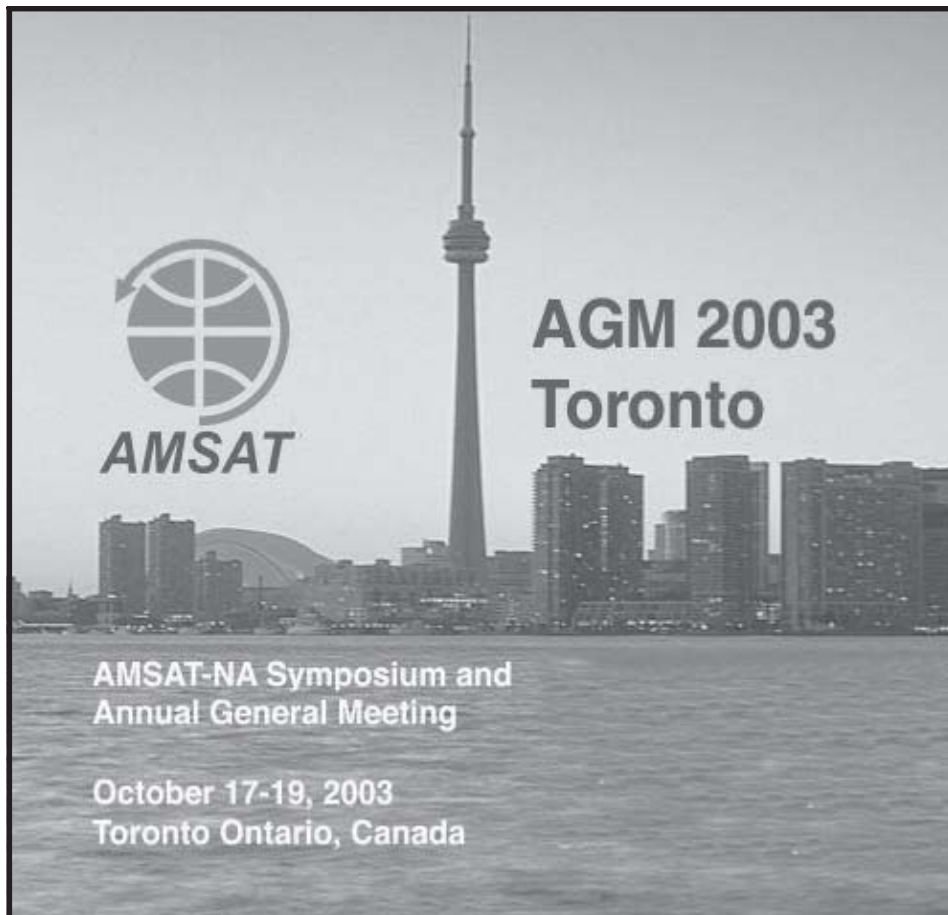
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“To Inspire the Next Generation of Explorers ...”

By the 2002 AMSAT Symposium Education Program

To inspire the next generation of Explorers - so begins NASA's educational mission statement as stated by Sean O'Keefe, NASA Administrator, in a keynote address in April 2002. NASA, the American Radio Relay League, and AMSAT are partners in bringing space to school-age children around the world via the ARISS project.

ARISS Chairman, Frank Bauer, KA3HDO, explains, “The unique, hands-on nature of the Amateur Radio contact provides the incentive to learn about orbital mechanics, space flight, and radio operations. This is the best educational outreach program at NASA.” A coordinating teacher said, “To see the kids' eyes light up, it was worth everything we've done to see that. This is



(above) Tony AA2TX, the inventor of the Disposable Antenna for AO-40, checks out the student built 2.4 GHz pyramidal horn antennas.



(left) “Measure twice and cut once and not the other way around”. Tony shows Glendon KD5OJH and Carolyn how to locate the feed horn.

something they will remember for the rest of their lives.”

The American Radio Relay League's *Amateur Radio Education and Technology Program*, also known as the “The Big Project,” is bringing Amateur Radio into the classroom down here on earth. Jerry Hill, KH6HU, the ARRL Program Coordinator for the Big Project, describes the program as “a million-dollar multiphase program based upon partnerships between educators and radio amateurs as mentors in classrooms, enrichment programs, and after-school activities.” The League's goal is for the Big Project to have 300 schools participating in this program by 2006.

(below) L-R: Peggy KD5OJF, Sanlyn KD5LXO, Sebastian KD5SXC, Allie, Mollie, Andrea, and Alicia. You really are supposed to look inside as Sebastian is demonstrating. He's checking for electromagnetic leaks by seeing if any stray light has entered the horn antenna.





All photos courtesy Tom Clark W3IWI

(left) L-R: Dylan KD5SXA, Allie KD5TWH, Alicia KD5RQD, Andrea (ham-in-training), Tony AA2TX, Glendon KD5OJH, Alejandro KD5SWY.

(below) L-R: Allie, Andrea, Tony, Alejandro, Sanlyn, Glendon.

Space, education, Amateur Radio, and a group of sixth graders eager to learn all came together at the 2002 AMSAT Space Symposium's Educational Program in Fort Worth, Texas last November, thanks to the efforts of AMSAT members Keith Pugh, W5IU; Anthony (Tony) Monteiro, AA2TX; and Kent Britain, WA5VJB. Tommy Davis, W5TCD, and Bill Penny, WM5U, of the Lockheed Radio Club were also contributed. Through Rosalie White, K1STO, at the American Radio Relay League, Keith met up with teacher Sanlyn Kent, KD5LXO, at the DeGolyer Elementary School in Dallas, Texas. The school participates in the ARRL Big Project. There are now over 30 licensed hams (two teachers, three parents, and the rest students) at DeGolyer school.



To view the entire collection of photos from the AMSAT Education Activities at the 2002 Space Symposium please visit: http://www.pbse.com/tomcat/kids__amsat (note that's with 2 underscores)



L-R: Dylan, Alejandro, Mollie KD5RQH, Andrea, Allie (back of head), Alicia, Carolyn, Tony.



(left) Carolyn and Glendon shown assembling the pyramidal horn antenna.

Keith started the ball rolling in August 2002 while performing his duties as the 2002 AMSAT Symposium Chair. "Tony's paper, 'A Disposable AO-40 Antenna' along with Kent's article on the 'Cheap Yagi', offered potential for student involvement," Keith recalled. Tony agreed to help with the project and Kent contributed his expertise in antenna construction and measurement.

Tony's "disposable antenna" is a 2.4 GHz pyramidal horn antenna made from cardboard and aluminum foil. He also has a design for a 435 MHz corner reflector antenna using the same materials. (Tony will describe his design in detail in an upcoming *QST* article.) His paper is also published in the in the 2002 *Symposium Proceedings*. Kent's 435 MHz cheap Yagi antenna, made from wood and wire, has been featured in *CQ VHF* magazine.

Teacher Sanlyn Kent, KD5LXO, said, "The kids loved the hands-on experience of building the antennas and that is probably the most important element needed to hook young hams. Hands-on activities are by far the most effective way to involve and teach children in today's busy world." She also reminded amateurs that, "A good school program is going to need *both* an experienced teacher and experienced hams working together to succeed. We need good Elmers."

Keith summed up his Elmer experience by saying that he found working with the 6th grade group rewarding. He also added that he will be following up with the DeGolyer School to help them with the dish and downconverter they purchased while they were at the Symposium. ■



Keith W5IU shown giving the DeGolyer Students a satellite operating demo in the Lockheed Radio Club station W5SJZ.



Kent, WA5VJB, shown helping with his 435 MHz Cheap Yagi antenna

Satellite DX by Wayne Estes, W9AE

This is a new column devoted to the pursuit of contacting new and/or rare countries via satellite. Readers with information for future columns are encouraged to send contributions to w9ae@amsat.org.

Recently there has been increasing interest in satellite DXing, particularly on AO40. The "good squint" period for the last couple months has given us long operating windows and lots of DX opportunities. But LEO satellites can also provide DX opportunities.

RECENT SATELLITE DXPEDITIONS

During the month of January, two satellite DXpeditions were of interest to North American satellite operators. First was the VP5/W6XX operation in the Turks and Caicos Islands on UO14 during the first week of January. A summary and photo of this operation can be found in the sidebar article. This operation is a good example of how successful a simple, casual LEO operation can be.

On a more ambitious scale, Howard G6LVB made a weekend trip to the Bailiwick of Jersey to activate a new entity on AO40 with the callsign GJ6LVB. Howard used his famous homebrew 4-foot umbrella dish and an 8x8 "cheap yagi". In two days Howard gave a "new country" to dozens of satellite operators. His uplink signal was a bit weaker than usual, but he still attracted HF-style pileups at times.

FUTURE SATELLITE DXPEDITIONS

JW (Svalbaard), February 24-March 1. Three Swedish hams plan to operate from the club station in Longyearbyen. They will be equipped to operate AO7, AO10, UO14, FO20, and FO29. Assuming AO10 isn't usable, they will only have windows to the Eastern and North Central portions of North America. QSL to the announced home callsign. Unfortunately, AO40 is not possible there because of the arctic latitude. The maximum elevation of AO40 from Svalbaard is only about 1 degree.

FG (Guadeloupe), February 21-26. Wayne Estes W9AE plans to operate AO40 as FG/W9AE from the Caribbean island of Guadeloupe. The tentative plan is to operate

starting ~2300 UTC on February 21, 22, 25, and 26 for windows to the Americas and the Pacific. Also on Sunday February 23 from 1500-2000 UTC for a window to Europe and central Asia. Exact operating times will depend on the RUDAK schedule and vacation activities. QSL to Wayne Estes, 18673 W. Meadow Lane, Mundelein IL 60060, U.S.A.

VP6D (Ducie Island), March 8-15. Doug Faunt N6TQS is a member of a multi-national team that will activate Ducie Island with the callsign VP6D. Doug will bring equipment to operate AO40, making this the first-ever satellite operation from the newest DXCC entity. The exact dates of operation will depend on weather conditions as the vessel Braveheart makes the long voyage from French Polynesia via Pitcairn Island to Ducie Island. The QSL route has not been announced.

DX SCHEDULES ON AO40

Frank Cahoy K0BLT has been busy contacting foreign AO40 operators via email to arrange operating schedules on AO40. He recently had successful schedules with 5B4AZ, SV1AWE, LX2GT, YB0KYQ, and VR2XMT. Some of these contacts were at extremely low elevation, pushing AO40 DX to its limit! Frank encourages other DXers to announce any scheduled DX contacts to amsat-bb so that others will have the opportunity to work a new country.

NEW DX STATIONS HEARD

HA5BWN
CX2AAI
FK8HA and FK8VHY

QSLS RECEIVED

5K0Z (San Andres Island) cards have been mailed.
7X0DX (Algeria) cards have been mailed to those who specially requested black-and-white cards. On January 28 Mirek reported that 7X0DX photo QSL cards have been shipped from the printer to QSL manager DL4DBR. ■

Satellite on a Shoestring By Chet Jensen, VP5/W6XX

The main objective of our second DXpedition to the Turks and Caicos Islands was to operate the 2003 ARRL RTTY Round-Up. A secondary goal was to work the Deserving before and after the contest on HF CW, SSB, and SSTV as well as UO-14 satellite. My wife Karen, KA6REN, and son Aaron, W6ADJ, and I had traveled to VP5 in 2001 and thoroughly enjoyed working the massive HF pileups and snorkeling in the most beautiful water in the world.

Our first trip to VP5 took an interesting turn when John, K6YK, suggested that I attempt to contact him via UO-14. Please keep in mind that your humble correspondent was not (and is not) a seasoned satellite operator, but merely a novice attempting to complete a QSO with a local friend and fellow DXer. Unfortunately, I was unsuccessful in working K6YK in 2001, so I was more determined than ever to "make the grade" in 2003! (K6YK has short low-elevation windows with VP5 on UO14)

Readers should not expect to be regaled with tall tales of satellite DX records being broken using large, multi-element arrays and high-powered, multi-mode, computer-controlled radios. Instead, our portable satellite station was "primitive." The complete station consisted of my FT-51R HT (5 watts), K6YK's pre-amp and duplexer, and KR6DY's handheld Arrow antenna. Satellite tracking information was forwarded by K6YK via e-mail. The station was set-up on a dinner tray, which provided easy portability and a balanced surface (I felt like a butler serving tea!). The antenna was expertly handled by KA6REN. I found that Karen's innate ability to track satellites by ear (and hand), while adjusting for polarization shifts and elevation changes was truly the difference in making the contact! In fact, I challenge even the most advanced software programs to compete with her accuracy and reliability.

In the meantime, I handled the radio, called stations, adjusted the receiver to accommodate for the Doppler shift (using the "up" and "down" buttons on the HT), and switched between the 2-meter and 70cm VFO's (I am now ready to tackle the most difficult video games!). Thankfully, Ron, N6EE, acted as my "computer-less" logger. I had used a tape recorder in 2001, but Ron used pencil and paper in 2003! Indeed, this





Chet W6XK and Karen KA6REN team up to make a UO14 contact from Turks and Caicos.

DX adventure had become a three-person operation on the cutting-edge of technology!

In the final analysis, we worked 30 stations on both UO-14 and AO-27 in 2001 and an additional 24 stations on UO-14 in 2003. Yes, we did "make the grade" with K6YK, who received a hand-delivered QSL card to recognize his achievement (a new grid and DXCC country). I wish to thank all of the courteous satellite operators, and especially K6YK, and KR6DY, who made my neophyte DX experience "on the bird" very satisfying and equally exciting.
Vy 73! Chet W6XK ■



Satellite Awards

Bruce Paige, KK5DO, AMSAT VP-User Services & Awards Manager says that congratulations are in order for these satellite operators who qualified for:

OSCAR Satellite Communications Achievement Award

Don Hinte, KA5EYH, Award #360
Brock Thomson, KG6GMT, Award #361
James Jipping, W8MRR, Award #362
Alan Lyday, Sr., WC9C, Award #363
David Bird, KC7USS, Award #364
Jean-Claude Bernard, F6IXI, Award #365
Reinhard Sual, YB0KTQ, Award #366

AMSAT OSCAR Sexagesimal Award

Alan Lyday, Sr., WC9C, Award #126

South Africa AMSAT Award

Alan Lyday, Sr., WC9C, Award #US71

Bruce's article describing all of the satellite operator awards and how you can earn them will be in the next issue of the *AMSAT Journal*. In the meantime you can see these awards on-line at:

<http://www.amsatnet.com/awards.html>

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SSB Electronic USA features world class VHF - UHF - SHF equipment. The latest gear from: SSB Electronic, Kuhne Electronic - DB6NT, M2 Antennas, Beko Electronic, EME, Procomm, AIRCOM PLUS, AIRLINK, ECOFLEX and WINRADIO is available.

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AMSAT Members Reach Major SETI Milestone

I thought I'd offer a brief progress report on a little AMSAT effort that hits a major milestone sometime today. I'm speaking of the 167-member Team AMSAT effort on SETI@Home. Take a look at our AMSAT SETI page at http://setiathome.berkeley.edu/cgi-bin/cgi?cmd=team_lookup&name=AMSAT

You will find that our collective efforts have now accumulated 500,000 work units representing approximately 755 YEARS of computer time as the collective effort of 167 members.

These efforts have placed AMSAT in 90th position among all the 20,000+ teams around the world, and we are on the verge of overtaking the Univ. of Washington for 89th position (probably in January, 2003): http://setiathome.berkeley.edu/stats/team/team_type_0.html

For those of you who don't know about SETI@Home, it represents the world's largest distributed computing "engine". Each of the work units represents a chunk of wideband noise acquired parasitically (freeloading a data sample at whatever place the telescope is pointing for other scientific programs. Each "chunk", as explained at

http://setiathome.berkeley.edu/about_seti/about_seti_at_home_1.html, is a 10 kHz wide, 107 second long slice of the cosmic background noise seen at frequencies near the 21cm frequency (1420.405 MHz) of neutral Hydrogen. Your computer is turned into a high resolution spectrograph looking for carriers and pulses that might arise for intelligent life elsewhere in our galaxy. The process followed by the data being munched by some 4.18 million users around the world is outlined in http://setiathome.berkeley.edu/process_page/. In short, SETI@Home is scanning the band, hoping that ET is calling CQ.

The of the 4.18 million users around the world, AMSAT's band of 167 amounts to only 0.004% of the "universe", but we have contributed 0.068% of the total or 17 times the average for such a group.

Of the half-million work units produced by AMSAT, 7 individuals have all contributed more than 20,000 work units — WB5TUF, AA4RC, G1YYH, N4QQ, WB1BQE, K6CCC and KK4XZ. Their total accounts for nearly

half of the AMSAT effort. In AMSAT we might offer an ATTABOY award, but I'm not certain it is appropriate (<http://www.dilbert.com/comics/dilbert/archive/images/dilbert2002112192227.gif>).

In case any of the rest of you want to contribute to AMSAT's SETI@Home effort, go to the SETI@Home web page at <http://setiathome.berkeley.edu> and download the software suitable for your computer. Then after getting things running, go to the AMSAT page at http://setiathome.berkeley.edu/cgi-bin/cgi?cmd=team_lookup&name=AMSAT and click on JOIN on the top line. We won't refuse you (<http://www.satirewire.com/news/0106/seti.shtml>)!

Congratulations to all the members of Team AMSAT for helping us reach the half-million mark in the 20 or so months that we have been around.

73 and Happy New Year de Tom, W3IWI

ARISS Team Meets at Goddard

Members of the Amateur Radio on the International Space Station (ARISS) International Team met December 5-8 at the NASA Goddard Space Flight Center in Greenbelt, Maryland. Delegates represented partner countries, International Amateur Radio Union (IARU) member-societies and AMSAT organizations in Europe, Japan, Canada, Russia and the US.

"I was extremely impressed with the quality of the discussions at our meeting and the camaraderie of the international team," said ARISS International Chairman Frank Bauer, KA3HDO. "The ARISS Team really has come together to be a cohesive international team since we first met in 1996." Bauer also represented AMSAT-NA during the session, which was moderated by Roy Neal, K6DUE, a long-time advocate of Amateur Radio in space. ARRL Field and Educational Services Manager Rosalie White, K1STO, attended on behalf of the ARRL. AMSAT-NA President Robin Haighton, VE3FRH, was on hand as a delegate for Canada.

The delegates heard progress reports on various ARISS equipment proposals, including timing for certification and future delivery. The ARISS Team will begin a review of new project proposals to determine their feasibility as well as their benefits to NASA and to ham radio operators. The ARISS Team

must evaluate the work involved in bringing a particular project proposal to fruition and, perhaps equally important, determine if the developers have the required funding.

Among the more unusual Amateur Radio experiments the team plans to consider further are a plasma cloud experiment and another that would compare the performance of different solar arrays. Details were unavailable. ARISS Team members also expressed concerns about hardware proposals that had been initiated without ARISS knowledge or support, since NASA requires coordination of all ham radio activity via the ARISS Team.

Previously approved hardware projects are now being completed to make the most of the four Amateur Radio antennas now installed outside of the ISS Zvezda Service Module—the crew's living quarters. Operations on 70 cm could commence as early as next spring, and SSTV (SpaceCam) hardware could be launched later in 2003. Once it's in place, students will be able to see the astronauts via SSTV while in QSO with them. Future add-ons under consideration include enhanced digital 10-meter crossband operation using PSK-31 or full-duplex voice repeater operation.

Delegates re-elected Bauer as ARISS chairman, White as ARISS secretary-treasurer, and Gaston Bertels, ON4WF, as ARISS vice chairman. All will serve two-year terms.

ARISS is an international project, with US participation by ARRL, AMSAT and NASA.

(Thanks to the The ARRL Letter, Vol 21, No 49 for this information.)



SKN Reminder

If you have not already done so, please take a moment to nominate your choice of the Best Fist you worked on OSCAR Straight Key Night. Please address nominations by e-mail to w2rs@amsat.org, by packet radio to W2RS @ WA2SNA.NJ.USA.NA, or by postal mail to W2RS's Callbook address.

continued on page 29 ...

Build This No-Tune Dual-Band Feed for Mode L/S

By Gerald R. Brown, K5OE, (k5oe@amsat.org)

The AO-40 transponder has two uplink receivers active most of the time for CW/SSB activity. Most operators use the “U-band” at 435 MHz (70 cm). Also available, however, are two L-band (23 cm) receivers: L1 at 1269 MHz and L2 at 1268 MHz¹. The reasons for going to L-band can be varied, but there is no arguing the benefits in reduced antenna size and AGC suppression. The types of L-band antennas are varied as well. Many use helices. Others use beams and arrays of beams. Still others use dishes, small and large^{2,3}.

I recently acquired an antique UHF TV dish measuring 1.2 m in diameter. I wanted to use it to both receive on “S-band” at 2401 MHz (13 cm) and transmit on the uplink on L-band. I covered it with aluminum mesh and built a dual helix feed for it, but was unhappy with the L-band performance⁴. It seems the concentric helices interacted with each other to a fairly substantive effect. Having had very good success with a couple of patch feeds on S-band, I designed, built, and installed a dual-patch feed on a 1.5 m solid dish for Field Day 2002⁵. This arrangement worked superbly on uplink (with 25 W), but was embarrassingly deaf on receive. This second dual-band feed failure led me to experiment for months with different configurations, leading ultimately to the design presented here. The project goals were 1) good performance on both S-band receive and L-band uplink and 2) an easy-to-produce model using common hardware and simple hand tools.

Patches are better than helices as dish feeds. This revelation came to me while doing investigation and experimenting with helix antennas⁶. Whilst in the middle of this investigative foray, I saw the radiation pattern for the G3RUH patch feed published on James Miller’s web site⁷. When I modeled that pattern and input it into the W1GHZ feed pattern program, it produced an amazing 72 percent efficiency⁸. The best helix I ever modeled has about 60 percent efficiency. I8CVS recently ran his own antenna range tests of a design similar to the G3RUH patch and produced a similarly impressive pattern. Then I came across the “truncated corners” square patch design popularized by K3TZ⁹. This specific AO-40 design is attributed to 7N1JWV, JF6BCC, and JG1IIK; and there are references in the literature going back over a decade for this now-common commercial design. The first



Figure 1: The 1.2 m Dish with Dual-Band Patch Feed Installed

model I built outperformed my best helix-incup design by a full S-unit (delta over the noise) on my FT-100 portable setup¹⁰. Compared to a helix, the patch simply has better illumination efficiency with less spillover from side lobes.

Patch theory is beyond the scope of this article, but can be summarized as building a shape that resonates at the desired frequency, compensated in size by the capacitive inductance between itself and the reflector. A patch can be practically any shape as it basically acts like a parallel-plate transmission line¹¹. Current in the patch flows from the feedpoint to the outer edge(s), where all the radiation occurs. The reputed, but often disputed, circularity of the truncated corner patch is accomplished by effectively designing two antennas into the patch element (of two different diagonal lengths) and feeding them 90 degrees out of phase^{12,13}.

For my 1.2 m dish (Figure 1), computations tell me I can expect 21 dBi gain on L-band and almost 27 dBi on S-band with an assumed 50 percent efficiency:

$G = 10 * \text{Log}_{10}[h(4p/l^2)*A]$, where h =efficiency, l =wavelength, A =aperture of the dish¹⁴

$G = 10 * \text{Log}_{10}[0.50(4p/86.72^2)*(3.14*576)]$, where $A = \pi r^2$
 $G = 10 * \text{Log}_{10}[0.0724*1807]$
 $G = 21.2 \text{ dBi at } 1269 \text{ MHz}$

$G = 10 * \text{Log}_{10}[0.50(4p/24.5^2)*(3.14*576)]$
where $A = \pi r^2$
 $G = 10 * \text{Log}_{10}[0.2564*1807]$
 $G = 26.6 \text{ dBi at } 2401.5 \text{ MHz}$

Where does the feed get mounted? The *focus* is where the parabolic shape of the dish concentrates the reflected signal. In my example the antenna was placed flat on the garage floor to measure the depth, and thus we can determine the following:

$f = D^2 / 16d$, where D =diameter of the dish and d =depth of the dish¹⁵
 $f = 48^2 / 16*7.25 \text{ (inches)}$
 $f = 2304/116$
 $f \gg 19.8 \text{ in. (50.5 cm)}$

This is just one version from the countless combinations of hardware and patch

designs. Inherent in this design, however, are five key design and construction features developed from building and empirical testing of a number of patch feeds.

1. The specified dimensions are critical for no-tune operation. Figure 2 depicts the dimensions necessary to build the dual-feed patch. (I recommend you reproduce this sketch accurately on graph paper. When you cut your patches you can lay them on the paper template for checking.) Repeat: the dimensions are critical. Even a 0.5 mm error will throw your resonance off considerably — patches are not broadbanded.

2. The reflector must be rigid. Spacing between the driven element (patch) and the reflector affects the resonant frequency. I found 0.025" aluminum sheet and 26 gauge copper sheet acceptable for a single S-band patch feed, but too flimsy for an L-band reflector. Use more rigid material or provide additional stiffening for the L-band reflector, as shown in Figures 3, 4, 5 and 6.

3. The patches must be electrically isolated from each other. A metallic center support works for a single patch but creates harmonic coupling problems when patches are stacked for multi-band use. The use of nylon machine screws and nuts may solve the vexing problem of the S-band patch coupling to the L-band patch.

4. The "straight corners" of the truncated corner patch must be kept clear of any proximate metal. This includes the edges of the feed support or "cup," if used. See Figure 5.

5. Feeding the patches at 90 degrees to each other minimizes the electromagnetic interaction between the two antenna fields.

One final design issue deals with the first harmonic of the L-band antenna: You must select a method to significantly reduce the potentially destructive effect from the 1269 MHz signal's first harmonic. Severe desense of your receive signal can occur and potentially even overload and damage the first active device in your system. Sensitive preamps and downconverters without a pre-RF-amplifier filter will need an external filter installed. I've used a G3WDG stub filter rated at 100 dB rejection with good success ahead of my preamp¹⁶. My current setup, however, uses a TSI 3731AA downconverter with its internal combline filter providing adequate filtering¹⁷. Using the downconverter directly at the feed has a noise figure (NF) of 1.0, compared to the

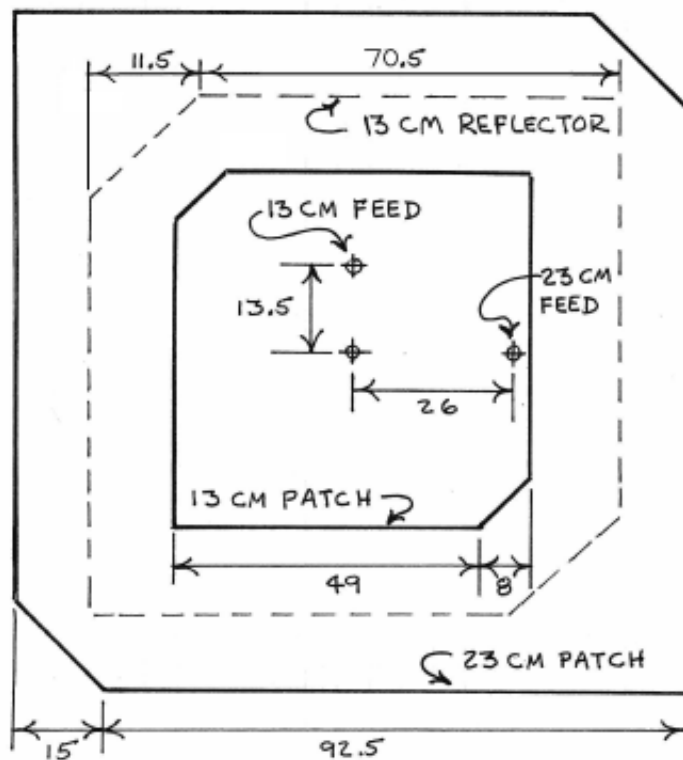


Figure 2: Dual-Band Patch Feed Dimensions (mm)

cumulative NF of 1.6 using a filter and a preamp.

Construction of the feed begins with selection of material for both the electrical parts (the antennae) and the mechanical parts (the support structure). The L-band antenna is constructed using a 6" x 6" double-sided circuit board for the reflector and a piece of 26 gauge copper sheet for the driven element (patch). A flanged female N-connector is used for the feed connection. The S-band antenna is constructed of two pieces of 26-gauge copper sheeting and the feed connection is made with a short piece of UT-141 (0.141" copper-clad semirigid conduit) terminated in a male SMA fitting. Figure 3 illustrates the assembly of the L-band reflector with the nylon-center support bolt, the L-band N-connector, and the S-band semirigid coax terminated onto an SMA-to-N adapter through the circuit board.

The support structure began life as a "virgin" paint can, measuring 155 mm in diameter and cut down to 15 mm depth. A hole was cut into the middle of the bottom of the can and the PC board is trimmed to fit inside the can bottom. Stainless #4x3/8" bolts, washers, and nuts were used to secure the PC board to the can bottom. A #6x1-1/2" nylon bolt is secured through the center

of the PC board with two nylon nuts to provide the requisite 6 mm spacing for the L-band patch. Figure 4 shows the L-band patch in position and ready to be soldered to the N-connector. Note the hole through the L-band patch allowing the S-band UT-141 coax to pass (without making contact).

The remainder of the antenna is then assembled in order: First the L-band patch is secured with two nylon nuts and soldered to the N-connector; then the S-band reflector is secured with one nylon nut to provide 3 mm spacing, and the UT-141 coax shield is soldered to the S-band reflector; and finally, the S-band patch is secured with a single nylon nut (3 mm spacing) and soldered to the center conductor of the UT-141 coax. To repeat the order: L-band reflector, two nylon nuts, L-band patch, two nylon nuts, S-band reflector, one nylon nut, S-band patch, and one nylon nut.

An electrical check with an ohmmeter of the completed feed should show the two reflectors connected, with the patches isolated from the reflectors and from each other. Figure 5 depicts the completed feed. Note how the sides of the support are cut out to avoid proximity to the L-band patch and how the L-band and S-band patches are at 90 degrees to each other. Figure 6 shows the back of the feed, complete with

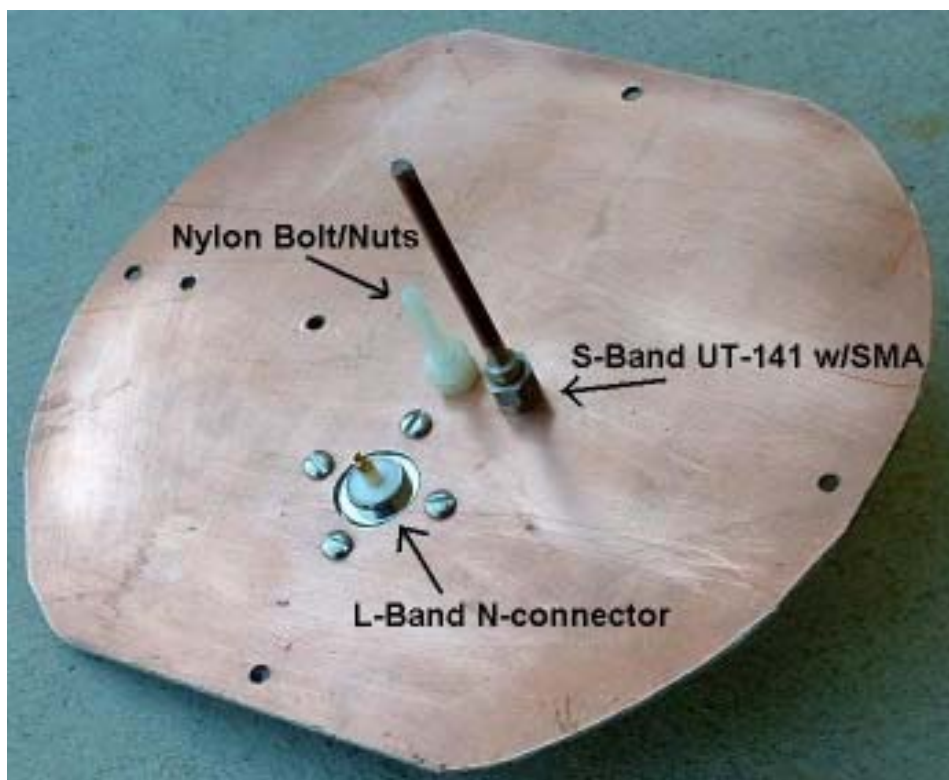


Figure 3: Assembly of the L-band Reflector

an angle support for the downconverter. The flanged N-connector is for the L-band coax and the male-N adapter is secured from the other side of the feed with the SMA fitting on the UT-141 coax.

For those tempted to tune the patch, I recommend doing it with the feed installed on the antenna — as the dish surface affects the feedpoint impedance slightly. The feedpoint impedance, and thus the resonant frequency, can be changed quite a bit by adjustment of the spacing of just the straight

corners. No need to change the spacing at the center or the feed — just a slight up or down bending of the straight corners will change the tuning. Do this carefully: a little bit goes a long way. This patch design is very repeatable and will work adequately (an SWR below 1.5:1) with no adjustments.

The antenna performs to both my expectations and the calculated predictions above. On receive, this antenna performs at 4 S-units better than my 45 cm dish and 3 S-units above my 65 cm dish (both other dishes have similar patch feeds and the exact same downconverter). It also clearly outperforms my previous dual-helix arrangement on the 1.2 m dish, but I was unable to do a side-by-side comparison. On transmit, it does equally well, with a decent signal into the satellite with only 10 W measured at the antenna. The L-band is noticeably improved over the helix predecessor. At low squints I find the L-band uplink to be about 1 S-unit weaker than my U-band uplink. I later added a small plastic hat to extend over the top of the patches to keep the rain and bird droppings off - *both* detune the patches when built up between the patch and the reflector.

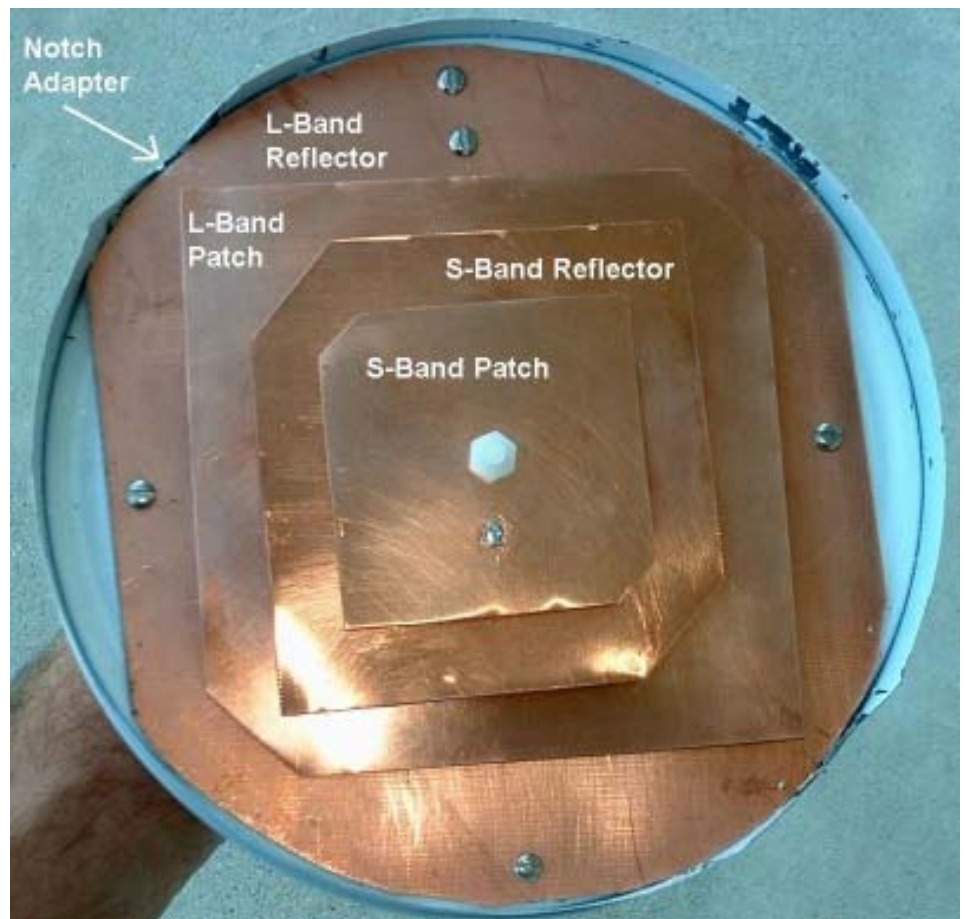
Though simple and effective, this is merely one way to construct a dual feed. Cookie tin lids also make excellent supports. Tin snips are a good investment and much easier to use than a hacksaw. A flat file is



Figure 4: The Support and L-band Reflector and Patch

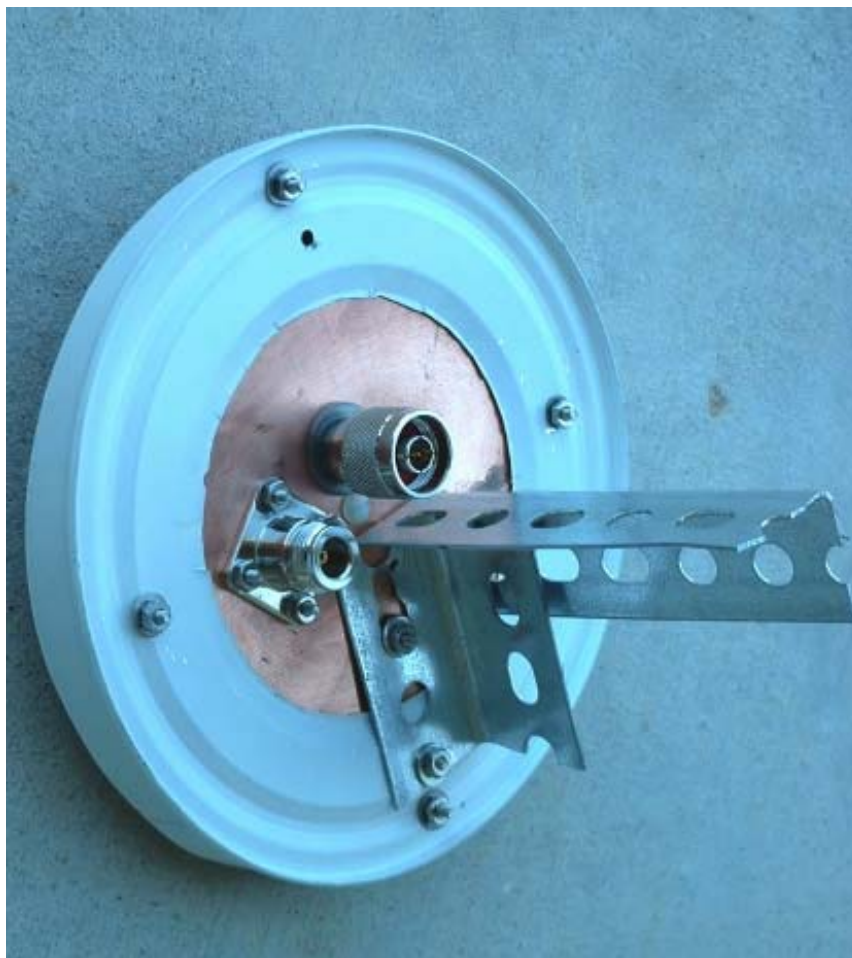
then used to remove burrs from the edges of the patches. Stainless steel hardware was used, most notably #4x3/8" machine bolts and nuts for the antenna hardware and #6x 1/2" for the support-structure connections to the support arms (1/2" aluminum tubing). The copper sheet is *much* easier to solder to than the aluminum. Once completed, the feed received a few coats of white enamel to protect the copper and to minimize the visual reflections.

This is not the only dual-band antenna on AO-40. There are many varied, innovative designs available as further food for thought, including G6LVB's simple and effective 1.2 m home-brew stressed "chicken wire" dish with a dual G3RUH helix feed¹⁸. G3WDG has a 3 m dish with L/S-band helices and a K-band (1.3 cm) feed horn, and W0LMD has developed some popular dual- and tri-band "round" patch feeds^{19, 20}.



(above) Figure 5: The Completed Dual-Band Patch Feed

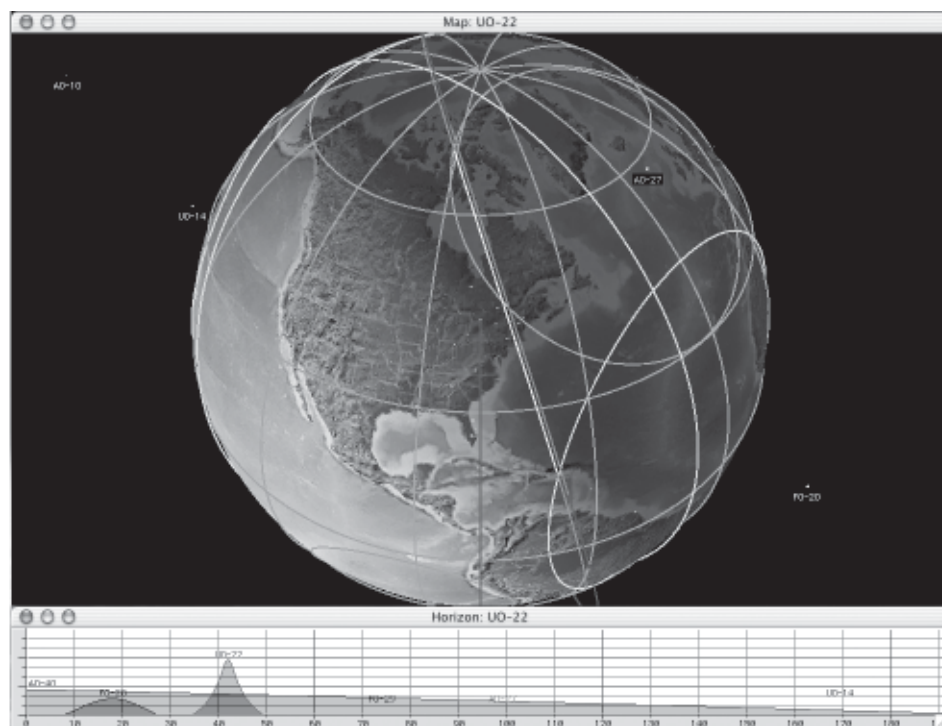
(below) Figure 6: Rear Of Completed Feed



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Environmental Factors Affecting AO-40 Reception

By G. Gould Smith, WA4SXM
wa4sxm@amsat.org

AO-40 has forced many amateur satellite operators to become knowledgeable about equipment and operation in the frequency spectrum above 70 cm. As we learn to operate on S band and K band we find out that, "We're not in Kansas anymore." The trip is an interesting one because principles and theories that have not played as important a role in operating the lower frequencies now become incredibly important.

AO-40 has presented us with a golden opportunity to learn about and experience operation and theory on the higher frequencies. As we become familiar with S band operation, we can see the benefits of the vast bandwidth we have there and begin to explore new ways to make the most use of it.

Background

After purchasing and mounting a new K5GNA 2.4 GHz receiving system, I woke up at 4:00am to operate it, there was single-digit squint but I heard nothing. I tried an hour later and could hear the beacon (barely), but couldn't even see peaks using the AO40Rcv software. I tried still later with squint into the teens... and the signal boomed in.

What was going on? Through the years I had noted a slight reduction in signal strength while operating the digital satellites and shooting through the trees. This hadn't caused me noticeable data loss because I was using high-gain antennas. Also, there was no noticeable difference over many years working AO-10 or AO-13 during different times of the day or in the summer and winter using Mode B and J. Why did the beacon suddenly get strong? Other than the frequency — what is different here?

The answer: 2.4 GHz and the trees. So let's investigate.

Understanding the AO-40 Orbit

First, let's look at the orbit of AO-40 and the advantages and challenges it presents. Using InstantTrack V1.54 and writing the ephemeris output to a file, do a 4-5 day sequence of tracking AO-40, import this into Excel, sort by azimuth and elevation, then plot. The loops are the perigee part of the

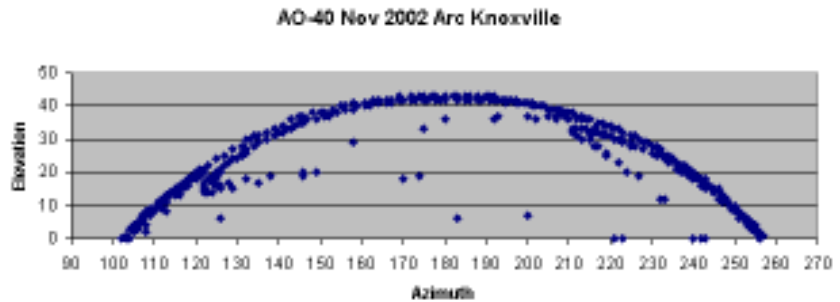


Figure 1: Basic AO-40 orbital tracking arc for mid-latitude U.S.

July 2002	43°	March 2003	48°
September 2002	42°	May 2003	50°
November 2002	43°	July 2003	53°
January 2003	45°	September 2003	55°

Table 1: AO-40 maximum elevation change 2002-2003 for Knoxville, TN

pass, so these can be ignored or edited out. Specifics on how to do this operation, with additional references, can be found at the end of my paper in the 2002 AMSAT Symposium Proceedings, available from AMSAT (or from me, via email). Figure 1 shows the basic arc that AO-40 follows for latitude 36° N in the eastern US (Knoxville, TN).

Plotting the AO-40 Arc

I redid the data gathering and plotting in two-month increments for the upcoming year. The data in Tables 1 and 2 (next page) show that the orbit arc remains basically the same for the US (selected cities shown in Figure 2). It will vary $\pm 10^\circ$ in azimuth and elevation over the next year.



Figure 2: Selected locations summarized in Table 2

Any environmental factors west to east, through north, will have no effect. Those with environmental obstructions to the south will have less of an obstacle because the satellite is at its highest elevation, 30°-50° above the horizon. The east and west parts of the arc pose the toughest challenge in terms of environmental obstructions, where the satellite is nearest the horizon.

AO-40 Arc Differences Nationwide

The AO-40 orbit changes very slowly except around perigee, usually 1°-2° in both azimuth and elevation every 11 minutes. Although slow compared to the LEO satellites, it also means that the satellite moves over obstructions, unless you live in a very satellite-challenged area. In Figure 3, note that the azimuth changes fastest (and the elevation changes least) around apogee, according to Kepler's law that the orbit must carve out equal areas over equal periods of time.

Remember that many natural and environmental factors can work against receiving the AO-40 S2 beacon, including:

- Distance
- Cosmic noise
- Atmosphere
- Mountains
- Rain, dust and sand
- Trees

Let's look at the effect each of these can have on AO-40 reception.

City	Lat	Long	Max El	Az range
San Antonio, TX	29.424	98.5	50	100-259
Knoxville, TN	35.93	84.04	43	102-256
San Jose, CA	37.338	121.893	42	103-257
West Hartford, CT	41.715	72.727	37	104-253
Bismark, ND	46.808	100.78	30	106-253

Table 2: Maximum AO-40 orbit elevation above horizon, selected U.S. cities

Distance

Free Space Loss formula:

$$L_{FSL} = (4\pi R/\lambda)^2$$

R = distance; λ = operating wavelength

Convert to frequency and dB the equation becomes:

$$L_{FSL\text{ dB}} = 92.4 + 20 \log f + 20 \log R$$

f = frequency in GHz; R = range in km

Notice in Table 3 that the path loss in dB for the 70cm at 60,000 km is the same as a 2.4 GHz signal at 10,000 km and the 25 GHz signal at 1000 km. Gene Marcus, W3PM, has included path loss in his exceedingly useful spreadsheet program that computes the anticipated signal strength of the AO-40 beacon. Of course, the hardware used to capture the signal and get it to the receiver is the most important part in recovering as much of this signal as possible. The spreadsheet can be found at:

<http://home.hiwaay.net/~mmarcus/download/ao40.xls>

Cosmic Noise

Stars and other deep-space bodies generate noise across the spectrum that competes with or dilutes the signal from the spacecraft. This noise is defined in degrees Kelvin and called Sky Temperature. The Nova for Windows program has a sky map that shows what background noise one can expect when pointing at various points in space. The map shows noise temperatures for 50, 130 and 400 MHz. In general, the VHF bands have higher noise temperatures than S band.

InstantTrack in the text mode shows the background sky temperature (TSky) if the 2.4 GHz beacon frequency has been added. Usually, this shows up as 3° K.

Path Loss in dB				
distance km	2.4 GHz	0.435 GHz (70cm)	1.2 GHz	25 GHz
1000	160.12	145.17	154.47	180.36
10000	180.12	165.17	174.47	200.36
20000	186.14	171.19	180.49	206.38
30000	189.66	174.71	184.01	209.90
40000	192.16	177.21	186.51	212.40
50000	194.10	179.15	188.45	214.34
60000	195.68	180.73	190.03	215.92

Table 3: Path loss at various distances in the AO-40 orbit

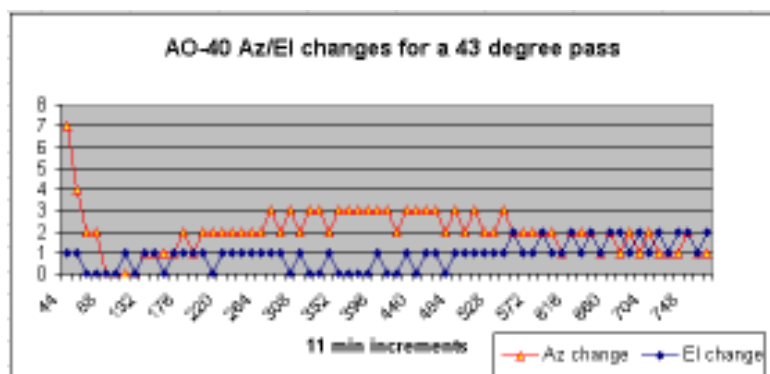


Figure 3: AO-40 Az/El rate of change

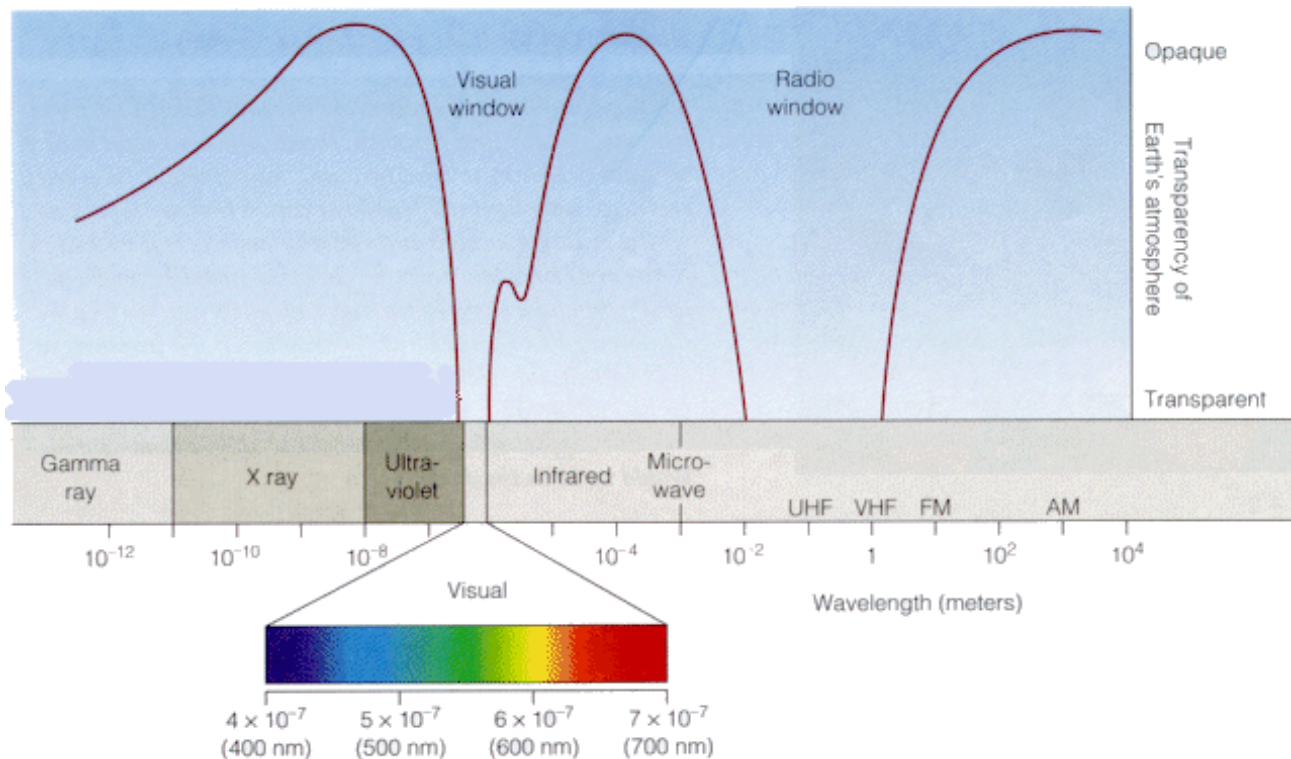


Figure 4: Electromagnetic transparency based on wavelength

At higher elevation angles the TSky noise is generated by the heavenly bodies. As the elevation angle approaches the horizon the noise originates from reflections off the terrain and side lobes. The *Amateur Satellite Experimenter's Handbook* has conversion information from °K to dB.

Atmosphere

The earth's atmosphere allows only certain frequencies to pass through. Figure 4 shows which frequencies of the electromagnetic spectrum penetrate the atmosphere. Note that there are only a couple of windows for this energy to reach the earth: one for visible light and one for VHF through microwave signals.

Atmospheric absorption at 2.4 GHz is minimal, but at 24 GHz there is a resonance for water vapor, with another for oxygen at 60 GHz.

Mountains and Buildings

Understandably, these pose quite a challenge to reception and in essence block the 2.4 GHz signal. Kulemin found that a 23cm brick wall would attenuate a 3 GHz signal 12 dB, and this quickly rose to 46 dB when the brick was wet. Reflections off these objects can cause strong signals to be received in places far from line of sight. For a fixed location signal this could be of

great benefit because a decent signal could be obtained by finding the reflected source. However, for a satellite signal that constantly changes location, it would be quite a challenge to track the reflection.

As the satellite angle changes one other benefit occurs: As the signal skirts the edge of an obstruction, the signal can diffract over the edge and provide coverage when there is no line of sight. Sadly, this is only temporary as the angle will quickly change and the effect is lost.

Rain, Dust and Sand

Rain has been recognized as a cause of unwanted signal attenuation in the millimeter wave region (3 to 30 GHz). Its effects vary depending upon the size of the drops and the rate of the falling rain. Higher GHz frequencies are more affected than the lower ones because the size of the raindrops can approach the wavelength of the signal. (Raindrops are generally on the order of 0.05 cm to 0.7 cm.)

Rainfall has proven to be inconsequential in the 2 GHz band, but increases in significance as the frequency increases. At 11GHz, rainfall imposes a severe attenuation upon the microwave signal. For more specific information check the Medhurst paper.

Dust and sandstorm research has increased in the last decade, due to the Gulf War. Sandstorms and dust storms are two quite different phenomena. What often occurs in arid regions and what are referred to as sandstorms are most times actually dust storms. Dust clouds of very dry soil often rise over a kilometer into the air and can obscure the sun for long periods of time. Sandstorms seldom rise more than 2 meters due to the higher density of the sand. In a sandstorm, the air is often clear at head level, with the sun shining. However, since both dust and sand particles are many times smaller than the signal wavelength, they tend to be insignificant, on the order of 0.5 to 1 dB for most of the UHF and SHF bands. Additional specifics can be found in the Comparetto paper.

Trees: The Foliage Effect

Those of us with trees around the house have met our greatest obstacle to AO-40 operation. There have been a number of studies done over the years for military reconnaissance and satellite reception to determine how much signal strength trees absorb. Lately, there has been quite a bit of interest in tree absorption studies because of the wireless networking, the 802.11 standard at 2.4 Ghz. Corporations and neighborhoods are interested in sharing a high-speed connection using RF networks.

The general consensus of the literature is that the shadowing from the canopies of even one or two trees gives rise to a major attenuation contribution. Signal fading from scattering and absorption from both branches and foliage are the primary contributors to signal attenuation.

Static measurements of attenuation attributed to specific species of trees have been performed at UHF, L band, S band and K band by Benzair, et. al. (1991), Butterworth (1984), Cavdar, et. al. (1994), Vogel and Goldhirsh (1986, 1993, 1994), Vogel, et. al. (1995), Ulaby et. al. (1990), and Yoshikawa and Kagohara (1989).

Measurements made by Cavdar, et. al. in Turkey in 1993 show the average attenuation and attenuation coefficients are similar at UHF and at L band for similar species of trees. (Refer to Table 4.)

The ITU-R (1994) measured long-path (ground-to-ground) and short-path attenuation (ground-to-ground or slant-path) through the foliage of a single tree with a foliage depth of 10-15 m. The study concluded that short-path attenuation coefficients were between 1-2 dB/m at frequencies between 1 and 4 GHz.

For a small to medium to tree, figure as follows:

UHF: 10.5 dB
L band: 11 dB
K band: 23 dB

Attenuation Figures Based on Foliage

Measurements done at 870 MHz show that attenuation due to full foliage is 35% larger than the corresponding attenuation for a similar tree without leaves. This suggests that the predominant attenuation at 870 MHz comes from the tree branches.

At L band, the measurements show only 15% additional attenuation due to foliage. At K band (20 GHz), the woody and leafy parts of the tree are both important, showing increases due to their effect from two to three times the treeless signal.

At 2.4 GHz, the wood of the tree is the major contributor to attenuation.

$$\tan \theta = \text{opp}/\text{adj}$$

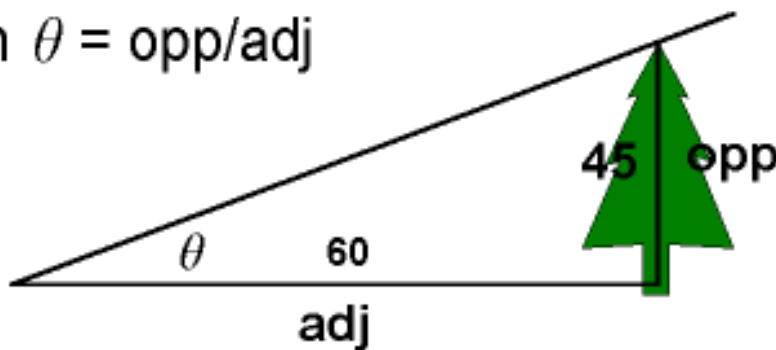


Figure 5: Use trigonometry to determine the elevation angle of the obstruction

Measuring Attenuation from 1 to 4 GHz

Benzair, et. al. found that full-foliage deciduous trees at frequencies between 1 and 4 GHz follow this relationship:

$$\text{MEL} = 0.79 f^{0.61}$$

MEL is the mean excess loss or mean attenuation coefficient in dB/m and f is frequency. This is about 1.5 dB/m at 2.4 GHz.

Determining Your Foliage-Induced Attenuation

Determine the distance through the tree(s) and multiply by 1.5 to get the attenuation of the trees.

For example, a maple in my yard has foliage 48' thick, meaning that it attenuates the 2.5 GHz signal as follows:

$$48 (\text{feet}) * 12 (\text{inches per foot}) / 39.37 (\text{inches per meter}) = 14.63 \text{ m} * 1.5 \text{ dB/m} = \mathbf{21.9 \text{ dB}}$$

That's one heckuva attenuation before it gets to the antenna.

Determining Your Foliage Effect

Generate an AO-40 plot using Excel, then go outside and map your trees, buildings and mountains against it. This will show you when you can best use the satellite. Follow these steps:

1) Use trigonometry to determine the elevation angle of the obstruction as shown in Figure 5, above.

2) Use an inclinometer (mechanical or electronic, my preferred method). Tom and Ray of NPR's Car Talk made a very clever observation a few months ago that fit right in with my philosophy: "Look at every home project as an opportunity to buy a new tool." So I actually got two new tools, as shown in Figures 6 and 7.

3) Mount a camera on your boom and move it while observing the trees, buildings and mountains, then record the Az/El and put this on your plot of the AO-40 arc (see Figure 8).

Tree Type	Average Attenuation (dB)	Attenuation Coefficient (dB/m)
Willow	10.45	1.1
Pine	18.0	1.8
Linden	9.1	1.4
European Alder	7.0	1.0
Acacia	6.75	0.9
Popular	3.5	0.7
Elm	9.0	1.2
Hazelnut	2.75	1.1
Maple	16.25	1.25
White Spruce	20.1	1.75
Laurel Cherry	12.0	2.0
Plane	16.9	1.35
Fir	12.75	1.5
Fruit	9.6	1.2
Average	11.0	1.3
RMS	5.1	0.35

Table 4 (Cavdar, et. al.) Tree attenuation at 1.6 GHz

In general, you would think that being close to a mountain range, hill or building would obscure most of the AO-40 orbit. But after practical measurements and calculations, this has proven not to be the case. From the data in Table 5 you can see that realistically these effects are minimal unless you are very close to the base of a mountain or building.

Improvements and Solutions

Cutting the trees – *not* always the best solution, especially if they aren't yours.

Increasing the height of your AO-40 down-link – thus reducing the angle.

Moving the antennas farther from the trees, leaving a lesser angle to the top of the tree.

Best of all, move the antenna back and up. This will do the most to reduce the elevation that the tree obstructs.

The object is to decrease the angle or $\tan Q$ to get above the tree. I now can work AO-40 from 117° to 232° , which is 115° as opposed to the 66° with the antenna at 10° , a marked improvement. Table 6 (upper right) shows various angle improvements increasing the antenna height and/or distance from the obstruction.

You can see from Figure 8 that I had a very restricted view of the satellite. In fact I could only work it from azimuth 140° to 206° , quite a restriction.

To improve my situation, I moved the antenna system up on to the roof, and attached it to an iron plumbing vent. The antenna went from 10' off the ground to about 23'. This made a significant

improvement in my AO-40 visibility. The comparison is reflected in Figures 9 and 10 (see following page).



Figure 6: Mechanical and electrical inclinometer



Figure 8 (above): Camera view of the antenna boom

Figure 7 (left): Using the inclinometer to determine the angle to the top of the trees

In Conclusion

Foliage has a dramatic attenuation effect upon the AO-40 2.4 GHz signal. Optimize your antenna placement to get the best view of the AO-40 arc.

Fairly minor changes in antenna location can make a vast improvement in AO-40 reception. ■



Figure 8: Author's view to the south

Mountain effect		Obstruction angle
700' above @ ~2 miles	700'/10,000'	5°
1500' above @ ~2 miles	1500'/10,000'	9°
4000' above @ 40 miles	4000'/211,200'	1°
4000' above @ 20 miles	4000'/105,600'	2°
Building effect		
6 stories @ ½ mile	60'/2460'	1°
12 stories @ ½ mile	120'/2460'	3°

Table 5: Realistic obstruction angles

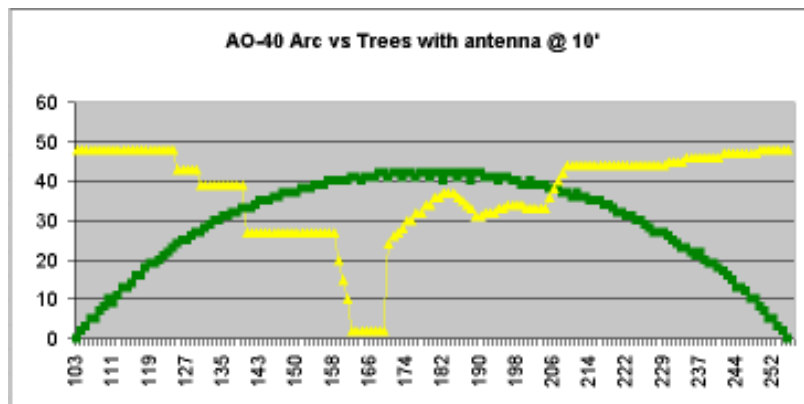


Figure 9 (above): Original antenna view of AO-40 arc

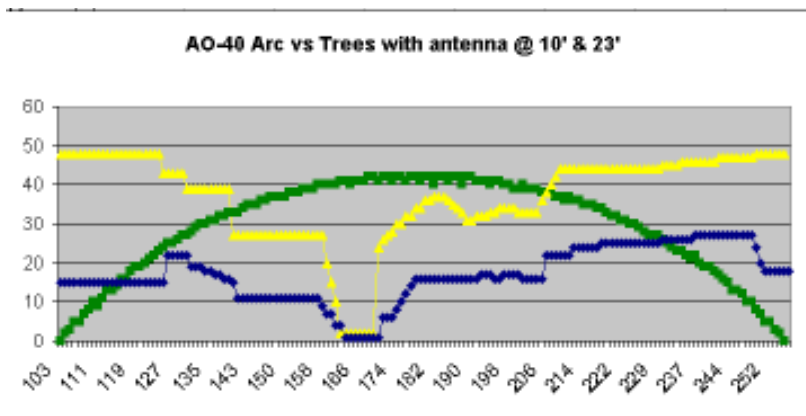


Figure 10 (left): The improved visibility with the antenna at 23°

Tree 60' tall		
Antenna height	58' from tree	70' from tree
6'	43°	38°
10'	41°	36°
23'	32°	28°
30'	27°	23°
40'	19°	16°

Table 6: Antenna position relative to the tree

2.4 GHz Ant. & Preamp for AO-40 or ATV

DEM 13LNAH Preamp
Ant. mounted, .6 dB NF
15 dB gain.....\$125

Andrews 26T-2400 Dish 24 dBi.....\$149 del
Rugged 2 x 3.4 foot cast magnesium/aluminum dish.
50 Ohm feed with N plug. Clamps up to 2" dia. masts.
Price is delivered UPS surface in contiguous USA.
HAMS: Ask for our free 10 page ATV Catalog!
We have it all, downconverters, transmitters, antennas, all mode linear amps, etc. for the 70cm thru 3cm ATV bands.
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AMATEUR RADIO ON THE INTERNATIONAL SPACE STATION— THE FIRST OPERATIONAL PAYLOAD ON THE ISS

By Frank Bauer, KA3HDO; Lou McFadin, W5DID; Mark D. Steiner, Carolynn L. Conley

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As astronauts and cosmonauts have adapted to life on the International Space Station (ISS), they have found Amateur Radio and its connection to life on Earth to be a important on-board companion and a substantial psychological boost. Since its first use in November 2000, the first five expedition crews have utilized the amateur radio station in the Functional Cargo Block (also referred to as the FGB or Zarya module) to talk to thousands of students in schools, to their families on Earth, and to Amateur Radio operators around the world.

This paper will discuss the development, qualification, installation and operation of the Amateur Radio system. It will also discuss some of the challenges that the amateur radio international team of volunteers overcame to bring its first phase of equipment on ISS to fruition.

INTRODUCTION

Prior to the development of the ISS, both the Russian and U.S. space agencies saw the significant benefits for having an Amateur Radio (ham radio) system on-board their vehicles. On Mir, the ham radio system served as a significant crew psychological boost for long duration missions as well as an emergency communications backup capability. In the U.S., the National Aeronautics and Space Administration (NASA) endorsed the education outreach and human spaceflight awareness capabilities that Amateur Radio on the Space Shuttle provided. Early in the development of ISS, NASA requested that an international consortium of ham radio teams come together and develop and operate a coordinated Amateur Radio system on the ISS. In 1996, an international organization called ARISS (Amateur Radio on the International Space Station) was formed to coordinate the construction and operation of amateur radio equipment on ISS. ARISS consists of a delegation from 9 countries including several countries in Europe as well as Japan, Russia, Canada and the USA. The organization is run by volunteers from the national Amateur Radio organizations from each of the nine countries and the international AMSAT (Radio Amateur Satellite Corporation) teams from each country.

ARISS represents a melding of the volun-

teer teams that have pioneered the development and use of Amateur Radio equipment on human spaceflight vehicles. The Shuttle/Space Amateur Radio Experiment (SAREX) team enabled Owen Garriott to become the first astronaut ham to use Amateur Radio from space, talking to hundreds of radio amateurs and heard by thousands

during the STS-9 space shuttle mission in 1983. Since then, amateur radio teams in the U.S. (SAREX and MAREX) Germany, (SAFEX), and Russia (Mirex) have led the development and operation of Amateur Radio equipment on board NASA's Space Shuttle, Russia's Mir space station, and the International Space Station.

Through ARISS, the ham radio community and others can talk to the astronauts and cosmonauts on-board ISS. The primary goals of the ARISS program are fourfold:

- 1) Educational outreach through crew contacts with schools,
- 2) Improving crew morale through random contacts with the Amateur Radio public and scheduled contacts with the astronauts' friends and families,
- 3) ISS-based communications experimentation and,
- 4) Promoting international good will.

To date, over 70 schools have been selected from around the world for scheduled contacts with the orbiting ISS crew. Ten or more students at each school ask the astronauts questions during the 10 minute orbital pass at the school location. Thousands of students participate in the school events each year. The nature of these school contacts embodies the primary goal of the ARISS program — to excite student's interest in science, technology and amateur radio.

The ARISS team has developed various hardware elements for the ISS amateur radio station. These hardware elements have flown to ISS on three Shuttle flights and one



Figure 1: FGB 2 Meter Antenna Locations

Progress flight. The initial educational outreach system supports voice and packet (computer-to-computer radio link) capabilities. Packet radio has several capabilities including an Instant Messaging-type system and a Bulletin Board System that allows radio amateurs to store and forward messages and allows the orbiting crew to send e-mail to all hams or to individuals.

In addition to the hardware elements flown on the Shuttle and Progress, the ARISS team supported Extra-Vehicular Activity (EVA) training, planning and operations to install four ham radio antenna systems.

HAM RADIO EQUIPMENT SPECIFICS

Ham Station Location

The ISS ham radio equipment will reside in two locations inside the ISS and one location outside the ISS. 2-meter (144 MHz) operations will primarily be conducted inside the Functional Cargo Block (FGB), named Zarya, using antennas that supported docking of the FGB with the Russian Service Module. These antennas, designed for use near the 2-meter band, (see figure 1) no longer support docking and can be used by the ARISS team permanently. This is the current location of the ISS ham radio station. The FGB radio system represents a minimal capability that allows the ARISS team to support school group contacts and packet communications on one band, the 2-meter band.

The ARISS team's vision of supporting sev-

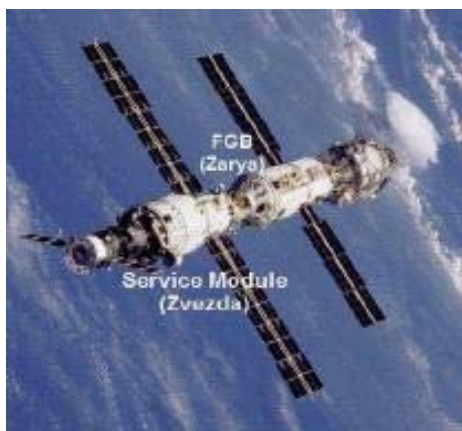


Figure 2: Service Module and FGB

eral different international users at the same time on separate frequency bands and different modes (voice, data, television, etc) requires several different antenna systems. The ARISS-Russia team provided this foundation through the installation of four ham radio antenna feedthrough ports on the Russian Service Module. With these antennas in place, the primary location of the ham station will reside inside the Russian Service Module (SM) named Zvezda. See figure 2. The ham station will be installed near the SM dining table. See figure 3. Simultaneous multi-band operations can be conducted with

these two (SM and FGB) station locations.

The ARISS team is also working with the international space agencies to install externally-mounted Amateur Radio equipment on the ISS. This hardware will enable to crew to communicate with Earth-bound radio amateurs and school students using handheld systems that can be moved throughout the ISS. It will also support communications experimentation that will enable students and radio amateurs to receive telemetry data from ISS.

Hardware Overview

Development of the ISS ham radio equipment was led by an internationally based set of volunteers primarily from AMSAT. The AMSAT team has developed and flown over 40 satellites since 1961. They were also instrumental in the development of the ham radio equipment that flew numerous times on the Space Shuttle (SAREX) and on Mir (Mirex).

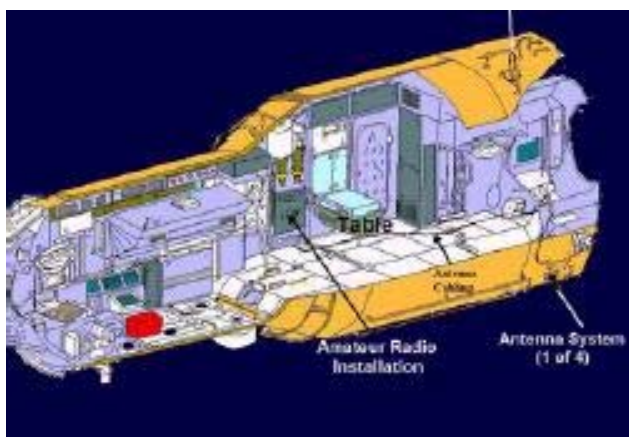


Figure 3: ISS Ham Hardware Location in the Service Module

The ham radio equipment was developed by modifying commercial off-the-shelf hardware for permanent spaceflight use. The USA team received safety certification support from Orbital Sciences Corporation. By utilizing several members of NASA Goddard's Hubble Space Telescope safety certification team during their "down time", the ARISS team was able to complete its safety certification in a lower cost (albeit slower) manner than having a dedicated safety certification team. Hardware validation and safety certification testing was performed at test facilities in the USA and in Russia. Our test facilities

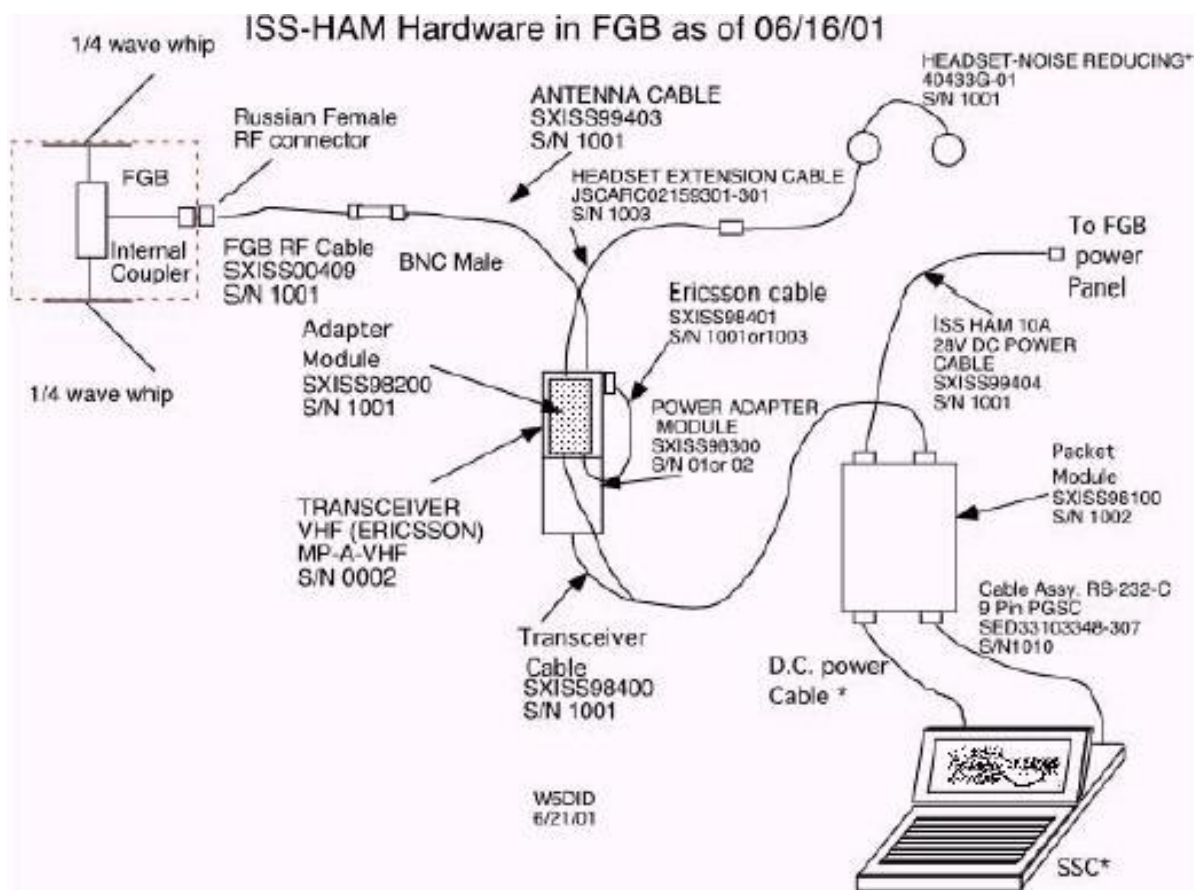
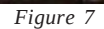


Figure 4: ISS Ham Hardware Configuration in the FGB

transceiver in place of the battery pack interface (see figure 6).

b. Adapter Module - Provides a means of inter-connecting the ISS Ham transceiver with the supplied headset assembly, as well as, a standard crew personal tape recorder. Provides the audio module and will interface with the SL hardware.



a. Power Adapter – The Power Adapter consists of a specially developed 12 V to 7.5 V DC/DC power converter that converts the 12 VDC received from the power supply in the packet module to 7.5 VDC that powers the transceiver. A 12.0-to-7.5 Switching Mode Voltage Regulator is built into a standard, polymeric Ericsson battery casing. The power adapter snaps onto the base of the

c. Computer—an IBM Thinkpad A22P computer, left on the ISS by taxi crew member Mark Shuttleworth, was connected to the packet module by Expedition 5 crew member Valery Korzun. This computer serves as a data terminal for packet radio operations. It will also serve as the video and software interface for the SSTV system that is planned to be deployed in the near future.

d. Packet Module—The packet module contains the primary power supply for the radio station. A maximum of 3 amps of current at 28 V can be provided to the various elements that make up the ISS Ham system. Embed





Figure 9: Headset Assembly



Figure 10: Equipment Cables

ded in the packet module is a PacComm Picopacket Terminal Node Controller (TNC). See figure 8.

e. Headset assembly: A David Clark aviation-type headset, similar to that used on several shuttle missions, was configured for the ISS ham radio station. See figure 9.

f. Cable interfaces: Several interface cables were specially developed to provide power, signal and RF connections between the antennas, radios, headset, packet system and computer. These interconnecting cables are depicted in the graphic (figure 4) and the picture (figure 10).

Follow-on Hardware Deployments

Additional ARISS hardware was deployed during two additional Shuttle flights and one Progress flight to ISS. This hardware included an additional Packet Module on the STS-105 Discovery flight on August 10, 2001, four Service Module antenna systems on the STS-108 Endeavour flight on December 5, 2001 and the Antenna cable clips on the Progress 6P flight on November 26, 2001. Specifics of this equipment are described below.

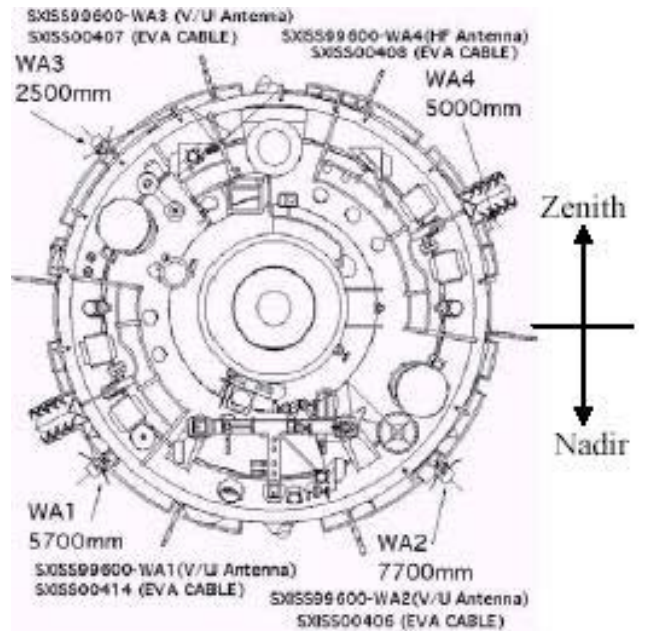


Figure 11: Antenna Location View from End of Service Module

Additional Packet Module

An upgraded packet module with new capabilities was stowed on the ISS in August 2001 and installed at the FGB radio station on February 21, 2002. The new Packet Module includes a specially developed Read Only Memory (ROM) with standard ISS ham defaults, Russian and USA labels, a new bat-

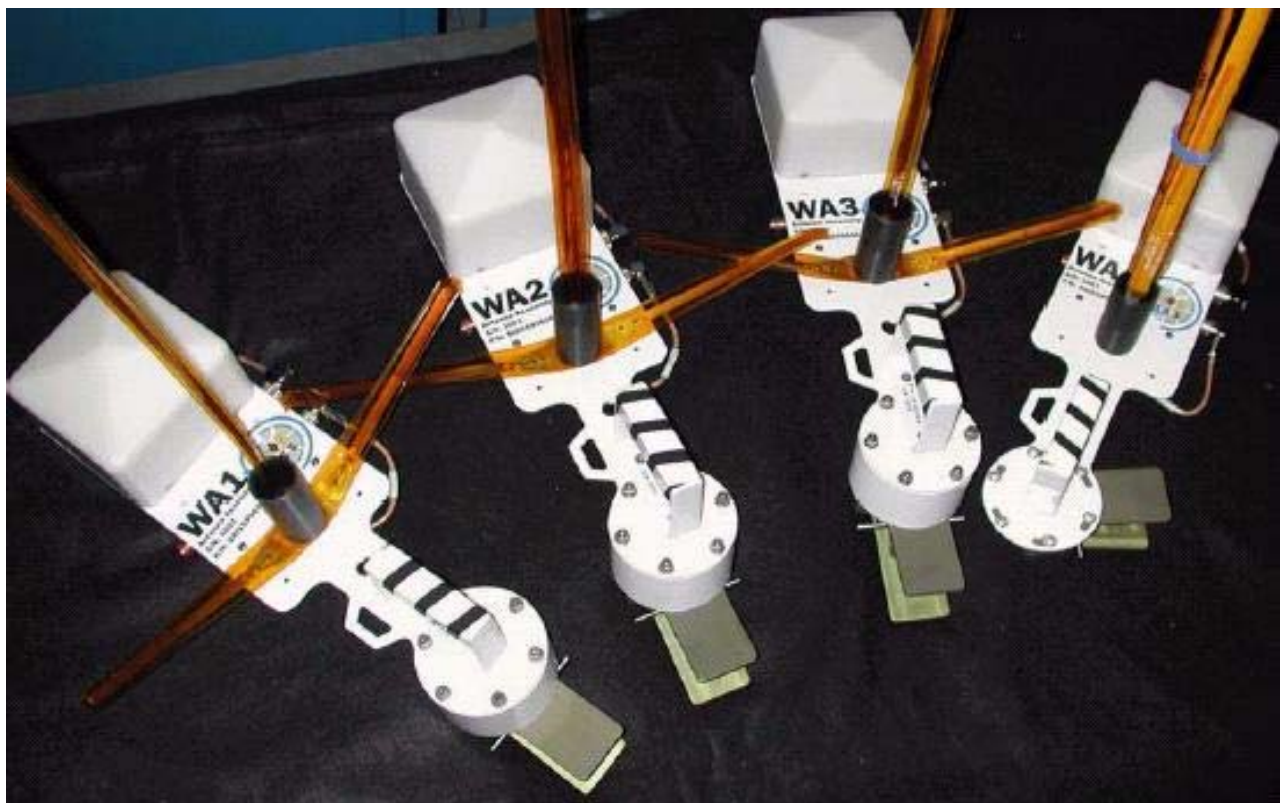


Figure 12: Antenna Systems WA1-WA4

tery, and extended memory (up to 1 megabyte). Since the packet module serves as the power supply for the ham station, the ARISS team has decided to leave both packet modules on-board ISS. This will allow the simultaneous use of the two radio systems, 2-meter and 70 cm, in the FGB and the Service Module respectively.

Antenna Assemblies

In 2002, a set of four antenna systems, developed by the ARISS team, were deployed during three Russian EVAs. Once checked out, the specially designed antenna assemblies will permit operations on HF (20 meters, 15 meters & 10 meters), VHF (2-meters), UHF (70cm), and the microwave bands (L and S band). These antennas also permit the reception of the Russian Glisser EVA video signals (2.0 GHz). This dual-use (Ham/EVA video) capability is the primary reason the ARISS team received access to the four antenna feedthroughs located on the outside of the Service Module.

A total of four antenna systems were developed to get maximum use of the antenna feedthroughs. These were installed around the periphery of the far end of the Service Module. See figure 11. Three of the antennas (WA1-WA3) include a VHF/UHF flexible tape antennas. WA4 includes a 2.5 meter flexible tape HF antenna. The antenna systems were developed by the U.S., Italian, and Russian ARISS partners.

Each antenna assembly consists of a mounting plate, spacer, a black striped handle, a Russian handrail clamp, an orange-colored



Figure 13: Antenna Handrail WA1



Figure 14: Russian EVA Connectors



Figure 15: Zenith Mounted Antennas on Service Module

VHF/UHF (or HF) metal flexible tape antenna with black delrin mounting collar, an L/S band flat spiral antenna with a white delrin radome cover, a diplexer (mounted underneath the plate) and interconnecting RF cables. See figure 12. The antennas will be mechanically mounted on Russian handrails, illustrated in figure 13, using the green-colored Russian "clothespin type" handrail clamp. RF connection is accomplished using 4 feedthroughs that have a special EVA connector attached. See figure 14.

The antenna systems were launched on the Space Shuttle Endeavour flight on December 5, 2001. The two up-looking (zenith) antennas, WA3 and WA4, were deployed in January 2002 and the two down-looking (Nadir) antennas, WA1 and WA2, were deployed in August 2002. The WA3 antenna was deployed by Yuri Onufrienko and Carl Walz during the first Expedition 4 crew EVA on January 14, 2002. The WA4 antenna was deployed on January 25, 2002 by Yuri Onufrienko and Daniel Bursch. On August 26, 2002, Expedition 5 crew members Valery Korzun and Sergei Treschev completed the installation of the final two antennas (WA1 and WA2). An on-orbit view of the two zenith mounted antennas, WA3 and WA4, is shown in figure 15.

The two Expedition crews performed extensive training of the antenna installation in the Russian Hydrolab water tank located at the Gagarin Cosmonaut Training Center (GCTC) in Star City Russia. See figure 16. Antenna installation on-orbit procedure development and training was led by Sergei

Samburov from Energia (also an ARISS-Russia team delegate) with support from the ARISS-USA team.

FUTURE HARDWARE DEPLOYMENTS

In the near future, a Slow Scan Television (SSTV) system and a next-generation (Phase 2) radio system will be deployed on ISS. These systems will provide more capabilities for the crew and permit simultaneous operations by more than one crew member. Other equipment, to be installed inside and outside the ISS, is currently being formulated, but won't be developed until their operation and use have been negotiated with the space agencies. The following describes the equipment expected to be deployed on ISS in 2003.

SSTV

The SSTV system for the ISS ham radio station is currently in development. This system will consist of a software interface, de



Figure 16: Training for EVA Antenna Installations

Initial Station Radio System Test Flow

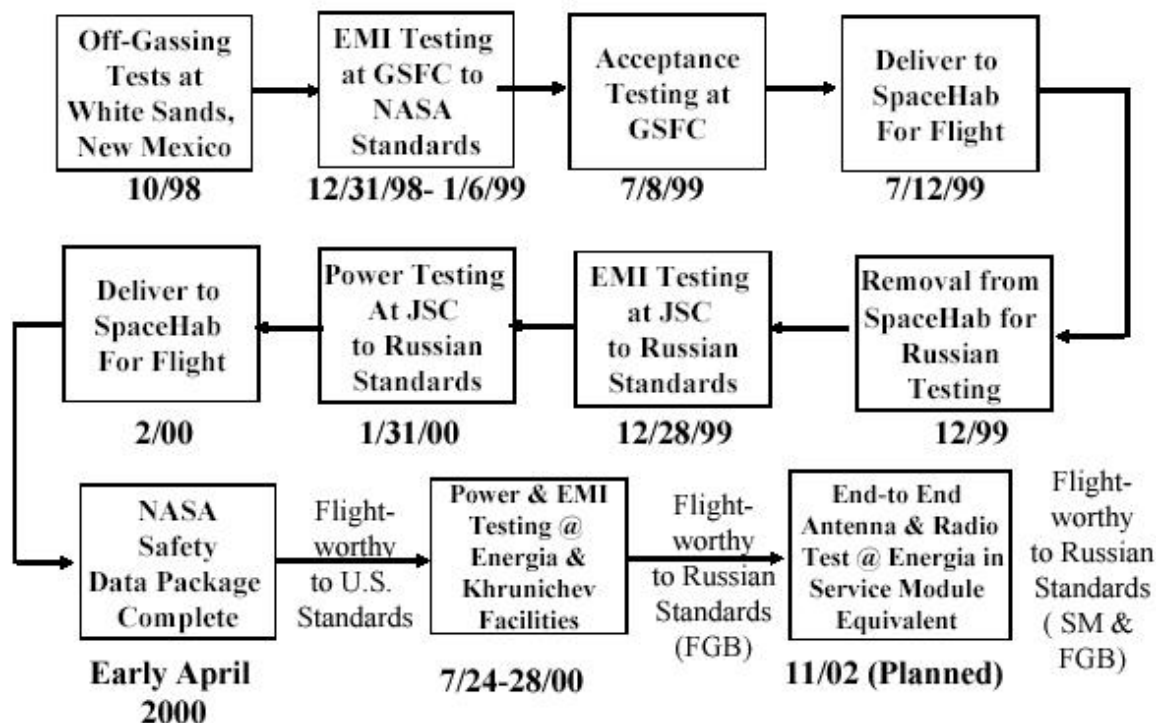


Figure 17: ARISS Test Flow

veloped by the MAREX-NA team and a hardware interface, developed by the AMSAT-NA hardware team. Prototype hardware and software systems have been developed and the flight system fabrication has started. The SSTV system will allow digital still pictures to be uplinked and downlinked in both crew-tended and autonomous modes. The ARISS team expects the SSTV system to be operational on ISS sometime in mid-2003.

Phase 2 Hardware

The Phase 2 hardware system is expected to exploit the new antenna systems installed on the Service Module. Two new radio systems will be installed as part of Phase 2. These systems will augment the 2 Ericsson radio systems already installed as part of the initial system. The Phase 2 development is being led by the ARISS-Russia team. One of the two radios currently being qualified for flight is a Kenwood TM-D700 radio. This radio supports 2 meter (144-146 MHz) and 70 cm (435-438 MHz) operation. This radio provides a higher output power capability (35-50 Watts) and can support FM and packet operations. The higher power capability should allow nearly horizon-to-horizon signal reception using simple hand-held radios or scanners.

The other radio is a Yaesu FT100. This radio

system will permit operation in the high frequency bands. Of particular interest is performing ionospheric propagation experimentation using the WA4 (high frequency) antenna and this radio. This radio also supports higher output power capabilities.

CHALLENGES

It has been said that when developing a project that the more interfaces required to complete that project, the more difficult, time consuming and expensive the project will be. This is acutely true when one considers an international venture where the different cultures and challenges encountered can seem to get in the way of progress.

After the first ARISS International Partners meeting in 1996, the team walked away from the meeting "cautiously optimistic" that we would be able to develop, deploy and operate an integrated ham radio system on the ISS. It was a good thing the volunteers involved in the hardware development and deployment had no idea of the significant challenges that faced them. The challenges that this international team endured were immense. We were the first payload to fly on ISS and no one—USA's NASA or the Russian Space Agency—really knew how we should be qualified. We repeated several flight qualification tests up to four dif-

ferent times to satisfy all the different organization's requirements—the Shuttle, the USA ISS team and the Russian ISS team requirements. Figure 17 depicts the testing performed to qualify the ARISS hardware. A couple of weeks prior to the September 2000 launch of the initial ISS Ham radio hardware, an additional stumbling block surfaced. The issue this time was that all the Russian EMI testing requirements were not completed. This issue was resolved through a test in Russia and the equipment was deemed worthy to be used in the FGB. The team is currently resolving certification issues to install and use the 70 cm radio in the Service Module. An end-to-end test is planned at Energia in late 2002 to certify the use of the Service Module antennas and Ericsson radios.

We also had to overcome the cultural difference hurdles that result from working as a fully integrated international team. At the onset, we all tried to "force" our individual cultures on the other teams. We quickly learned that to effectively work together, we must first understand each other's culture and then respect that culture as we worked together as a team. It was tough in the beginning but, over time, we have come to understand each other. This has allowed ARISS to be successful and work effectively as a team.

Communication within the international team continues to be a challenge, but not insurmountable. The significant differences in language between the 9 member countries pose difficulties in ensuring that there is consensus between the international partners. In an effort to minimize communications breakdowns, the Russian and USA teams who have hardware that will be flown on their vehicles have teleconferences twice a month. These teleconferences, with interpreters on-line, help to synchronize the ARISS activities being performed in the USA and Russia. We also have monthly ARISS teleconferences with the entire team on-board as well as face-to-face ARISS international meetings twice per year.

E-mail has also helped make team communication easier, but it has its drawbacks. The ARISS team has been continually plagued with the prevention of e-mail traffic reaching its destination due to Internet filtering and blocking as a result of the proliferation of Internet hackers and spammers. The team's access into the NASA and Energia team members, in particular, have been affected by this. These communication blockages slow down the ability to complete the hardware development tasks at hand and communicate effectively.

The ARISS team continues to get great support from the international space agencies and contractors. However, the volunteer nature of our work, at times, conflicts with the space agency's specific demands for immediate information as part of a flight critical system. The volunteer team's organizational structure is set up to facilitate getting critical information in a timely basis to the space agencies to meet their flight critical requirements.

Because we are an integral part of ISS, our team, at times, gets immersed in some international space agency issues. For example, when Dennis Tito, the first tourist to ISS, requested the use of our equipment during his stay on ISS, we worked with NASA, Energia and Mr. Tito's team to ensure that ARISS fulfilled the ISS international agreements and served Mr. Tito. In this case, some of the agreements were being heavily negotiated very close to the launch of the Soyuz, putting our team in an awkward situation. In the end, Mr. Tito was very pleased to use the ARISS equipment to talk to his family. The success of this activity and many others is a testament of the close, working relationship that members of our international team have with the space agency and Energia managers.

CONCLUSIONS

The ARISS-international team developed the first payload to become certified to fly on the ISS. Similar to the pioneers of old, this volunteer team faced significant hurdles along the way. They successfully and methodically overcame each issue to pave the way for future amateur radio endeavors on ISS. The hardware team's success on ARISS is a testament to their tenacity, international teamwork and drive to make amateur radio a permanent fixture on the International Space Station.

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For more information on the ARISS program, you are welcome to visit the ARISS web page at: <http://ariss.gsfc.nasa.gov>. ■

... continued from page 11

Telemetry

AMSAT Files FCC Petition for Rulemaking

The FCC invited comments on AMSAT's Amateur Radio-related petition for rule making. Designated RM-10621, AMSAT-NA has asked the FCC to drop its presently required 27-month pre-space notification to the FCC's international branch for Amateur Satellite launches and substitute a pre-space notification within 30 days of a launch commitment.

Although the comment deadline for the petition was January 17, 2003, interested parties may view the AMSAT petition on the FCC's Electronic Comment Filing System (ECFS) <http://www.fcc.gov/e-file/ecfs.html>.

FCC Launches Consumer-Oriented Electronic Comment Filing System

The FCC has launched ECFS Express, an updated electronic system that the Commission says will make it easier for some members of the public to file comments on FCC proceedings. ECFS Express is a simplified version of the popular Electronic Comment Filing System (ECFS), but it is not available for all FCC proceedings.

ECFS Express focuses on topics rather than docket numbers, and requires minimal input by consumers seeking to participate in the Commission's public rulemaking process. ECFS Express is accessible from the FCC home page at <http://www.fcc.gov>. Users click on the "File Comments" logo. Anyone who wants to comment just has to click on a topic, fill in their personal information, write their comments and hit "SEND."

The FCC said the downside is that if the particular issue you want to comment upon is not listed among the ECFS Express topics, you'll have to use the full version of ECFS, located at <http://www.fcc.gov/e-file/ecfs.html>, to comment on proceedings not listed.

FCC Consumer and Governmental Affairs Bureau Chief K. Dane Snowden said, "By making the process more intuitive and less technical, all those interested in what we are doing at the FCC can have their voices heard. Our goal is to have as much of the public as possible participate in our rulemaking processes."

AO-40 Operating Schedule Change

Stacey Mills, W4SM has updated the AO-40 operating schedule to adapt to the current operating conditions aboard the satellite. At MA 2, Orbit 1028, AO-40's middle beacon came on only very weakly until MA 55 when the S2 Tx was manually cycled off/on by a command station and came back on at full power. This has happened several times in the past and appears to be due to the S2 ALC. In this particular case, it may be related to the fact that the beacon was cycled back on only shortly after eclipse when the batteries were still relatively low and the temperature was still cold. We have modified the schedule to not turn the beacon back on until MA=10.

2002 Space Symposium Technical Results

Data Provided by Keith Pugh, W5IU, 2002 Symposium Chairman
With thanks to Al Ward, W5LUA (test equipment) and Kent Britain, WA5VJB (antenna range)

The 2002 Space Symposium gave satellite operators the opportunity to perform measurements which are not usually available in the average Amateur Radio station.

The Antenna Test Range measured the gain of antennas between 145 MHz up to 10 GHz.

Antenna Test Range Results

145 MHz		
W7LB	6 Ele VJB Cheap Yagi	12.2 dBi
W7LB	3 Ele Arrow	7.4 dBi
K0GCJ	Quadrafilair Helix with 30 ft of RG-8X built into the antenna	2.0 dBi
434 MHz		
WA5QGD	24 ele Cushcraft ATV Yagi	18.5 dBi
W7LB	10 element VJB Cheap Yagi	11.9 dBi
N5AFV	7 element Arrow	10.7 dBi
W7LB	7 element Arrow	9.4 dBi
W9AE	7 element X'd Arrow	4.8 dBi Vert 8.4 dBi Horiz
AA2TX	Cardboard and Aluminum foil "Throw Away" corner reflector with 5ft of coax built in	7.2 dBi
N7SFI	5 element Arrow	5.6 dBi
N5AFV	AL800 Prime Handheld	2.6 dBi
1296 MHz		
WA5QGD	45 ele Loop Yagi	19.0 dBi
2402 MHz		
WA5VJB	Narda Reference Hom	13.8 dBi
AA2TX	Corner Reflector made from Cardboard and Aluminum foil with probe feed	16.8 dBi
KC5ZDX	60 cm dish with G3RUH patch feed	18.0 dBi Horiz 16.6 dBi Vert **
W7LB	Grid dish with 3 1/4 turn G3RUH Helix feed	17.6 dBi Horiz 18.0 dBi Vert **
WA5VJB	1 lb Coffee Can	8.5 dBi
10.3 GHz		
K0OE	30 cm dish with WR-112 "Cutler" feed	31.0 dBi
WA5VJB	Narda Reference Hom	16.7 dBi
Notes: ** This antenna meets the definition of a circularly polarized antenna. (Several antennas had lengths of coax built into the antenna - gain numbers do not allow for loss due to this extra coax.		



The calibrated test station provided the opportunity to accurately measure gain and noise figure of downconverters and pre-amplifiers. ■

AMSAT 2002 NOISE FIGURE RESULTS, FT.WORTH, TEXAS NOVEMBER 9, 2002 Conducted by W5LUA of Agilent Technologies				
Call	Design	Device	Noise Figure (dB)	Gain (dB)
2401 MHz				
AA2TX	DEMI LNA	ATF-36077	0.28	17.80
N2CEI	DEMI LNA	ATF-36077	0.39	17.60
W2GPS	SSB LNA	SLN-2400	0.54	27.60
N8FGV	W5LUA HB LNA	ATF-36077	0.57	16.80
K0GCJ	DEMI CONVERTER		0.70	23.50
W5ACM	W5LUA LNA	ATF-10136	0.75	11.20
N8FGV	W5LUA LNA & CONV		0.85	36.00
W7LB	AIDC-3733 CONV		1.18	36.50
W2FS	CONIFER PA-1033 LNA		1.20	11.30
AA2TX	AIDC-3731A CONV		1.37	38.40
W5ACM	AIDC-3731A CONV		1.43	37.00
KC5ZDX	XM PREAMP	MACOM MMIC	1.86	30.50
KC5ZDX	LNA & CONV		2.00	40.20
W7LB	CAL AMP 31732 CONV		2.10	33.50
N8FGV	NORSAT 2500 CONV		2.75	21.60
24048 MHz				
W5LUA	HB LNA	NE32584C	2.05	15.50
W5LUA	AVANTEK LNA	PN SMW94-1044	2.23	28.90
W5LUA	HB LNA	AVANTEK	2.30	12.00
W5LUA	HB LNA	2 X ATF-36077	3.08	12.30
W0EOM	COMMERCIAL 23 GHz LNA	"149-0308-02, CSH 02610-002"	3.90	20.90
W5LUA	S94-46602 CONV W/FILTER	22.2-23.6 GHZ CONV WITH 1296 IF	6.90	22.20

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Dale Hershberger, KL7XJ, in Soldotna, Alaska, uses a **SatEL Az-EL!** to mount a 3' NSIYR circular polarization offset dish for his AO-40, 2.4 GHz downlink, and a M2 70 cm 11 element Yagi for his uplink. Dale is about to install a DEM RHCP helix for a 1.2 GHz uplink.

AZ-EL on a Budget! SatEL's Az-EL! with Control Processor and two Windows® drivers, seen at Dayton last May. "We do dishes!" (3 ft.)

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President's Letter continued from page 5 ...

Now for the good news! It seems that Echo will probably be launched sometime in a window starting in September 2003 and lasting through December 2003. More on this as we approach the launch.

73,
Robin Haighton VE3FRH
President AMSAT-NA



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